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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1922.

GENERAL PHYSICS.

427. Testing-Machines giving the Elastic Limit and the Modulus of Elasticity. R. Guillery. (Comptes Rendus, 173. pp. 907-909, Nov. 14, 1921.)—An arrangement to be attached to the test bar is described and illustrated diagrammatically. It consists essentially of two compressible water reservoirs, one controlled through a lever system by the relative motion of the ends of the test bar, the other by the tensile stresses applied. Both are connected with a common gauge tube, the level of the water in which tends to descend as the test bar elongates and to rise as the tensile stress increases. The adjustment of the lever system necessary to maintain a stationary level in the gauge tube at the commencement of the test, indicates, by means of a suitable scale provided, the modulus of elasticity, and, after this adjustment has been made, a fall of the level indicates the reaching of the elastic limit. A. B. C. L.

428. Comparison of Wireless Time-Signals. R. M. Stewart. (Roy. Astron. Soc., Canada, J. 15. pp. 282-285, Sept.-Oct., 1921.)—During part of Nov. and Dec., 1920, at the Dominion Observatory, Ottawa, time-signals were compared, not only with the U.S. Naval Station, Arlington, as customary, but also with Mare Island, Cal., with Darien, and with Lyons (France). These are published, though they failed to fulfil their purpose of obtaining corrections to adopted longitudes of the stations. The range of residuals is about $1\frac{1}{2}$ sec. for Mare Island, nearly $1\frac{1}{2}$ sec. for Darien, rather over $\frac{1}{2}$ sec. for the shorter Lyons series, and about $\frac{1}{4}$ sec. for Arlington. A table is appended giving the observed clock corrections at Ottawa. W. W. B.

429. Measurement of Pressure by Means of Hot-Kathode Tubes. W. Kaufmann and [Miss] Serowy. (Zeits. f. Physik, 5. 5 and 6. pp. 319-323, 1921.)—It is shown that a wireless amplifying valve may be used not merely to give relative pressure measurements, as in ordinary practice, but also to give, in conjunction with Mayer's curves [Abs. 894 (1915)], absolute pressure measurements for very low pressures. A. W.

430. Application of Mathieu Functions to Physical Problems. B. Pal. (Calcutta Math. Soc., Bull. 12. pp. 173-182, Dec., 1921.)—The author points out how the functions which have been so far developed can be made use of to solve definite problems. L. H. W.

431. Harmonic Analysis. W. Dällenbach. (Archiv f. Elektrot. 10. pp. 277-282, Nov. 15, 1921.)—This paper discusses the calculation of the components of an experimentally determined periodic curve. The accuracy of polygonal approximation, and of approximation by means of cubic parabolic arcs, is particularly dealt with. A. W.

432. Graphical Integration. M. Pirani. (Elekt. Zeits. 42. p. 1514, Dec. 29, 1921.)—Given the curve $y' = f'(x)$, it is required to obtain $\int_{x_1}^{x_2} y' dx = f(x_2) - f(x_1)$. This is accomplished by first dividing the area between the ordinates y'_1, y'_2 into a number of vertical strips and projecting the mid-ordinates of these strips on to the vertical (y') axis. The points thus obtained are joined to a pole arbitrarily chosen along the axis of x' produced in the negative direction. If α is the inclination to the horizontal of the hypotenuse of one of the triangles thus obtained, $\tan \alpha = dy'/dx = y'$, and hence the curve $y = f(x)$ is obtained by drawing a succession of lines, terminated by the lines separating the vertical strips, and inclined at the corresponding values of α . This process is facilitated by the use of one or other of two mechanical aids here described. The first of these consists of two straight-edges connected by a stiff hinge so that when set it may be moved without altering the angle. The straight-edges are graduated along their edges, which latter come together for zero angle. The second consists of a rectangular frame with arms pivoted at the two left-hand corners. One of these arms is for use on curves going below the x -axis, the other for curves above the x -axis. A strip of celluloid with a fine line down its centre passes from top to bottom of the framework, and may be moved sideways to adjust the pole distance to any desired value. A. W.

433. Law of Probability in the Variations in a Dielectric and the Absorption of α -Rays. W. Bothe. (Zeits. f. Physik, 5. 1. pp. 63-69, 1921.)—A continuation of previous work on modifications of the Gaussian equations [see Abs. 6 (1922)] in the two physical problems indicated in the title. It is shown that the Gaussian law cannot be applied in these cases, in spite of the large number of sources of deviation. The paper is mainly mathematical, and cannot be usefully abstracted. J. W. T. W.

434. The Heaviside Unity and Unit Impulse Functions. A. Press. (Electrician, 87. pp. 376-377, Sept. 23, 1921.)—In explanation of the type of generalised algebra contemplated by the symbolic methods employed in Heaviside's "Electro-magnetic Theory" [see Abs. 761 (1921)], reference is made to the Heaviside unity function. In considering the functions $y = x^m$; $U = x^{dm}$, U , the Heaviside unity function, may be defined as the limiting form of the prior function, as m approaches zero value from positive values of m only. The description and exemplification of the functions are mainly mathematical and should be consulted in the original. A. B. C. L.

435. Influence of the Manner of Loading on the Breaking of a Straight Rod. H. Zimmermann. (Preuss. Akad. Wiss. Berlin, Ber. 51. pp. 884-898, 1921.)—By considering the load as applied at a distance (a) from the axis of the rod, the solution of the problem of its deflected form is made determinate. In the case of the fixed-free rod the end deflection, δ , is given by $\delta/a = (1 - \cos a)/\cos a$, where $a = l\sqrt{(P/EI)}$. For any δ equilibrium is possible by proper choice of a , but the equilibrium is unstable unless $a < \frac{1}{2}\pi$, the usual Euler condition. The force, then, can be taken as axial, provided its moment be included in the applied bending moment. The same conclusion is obtained for the case of more than one span, and for elastic supports, and the stability conditions thus assume a more compact form. W. G. B.

436. Stress Distributions in Discontinuous Bars. E. G. Coker and P. Heymans. (Engineering, 113. pp. 26-28, Jan. 6, 1922. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—Describes results obtained by the photo-elastic method on the distribution of stress in discontinuous bars of various forms, such as the B.E.S.A. and Continental test specimens for tension tests, and in notched bars with various different forms of notch, such as the vee-notch, the Charpy, and the rectangular with rounded corners. The results of tests on these forms have been previously published [see Abs. 1654 (1921)]. The suggestion is made that the use of a plate with large circular hole instead of a notched bar might prove valuable for impact tests, since this form of discontinuity has been shown to give an approximately linear stress distribution across the minimum section [see Abs. 182 (1920)]. J. W. T. W.

437. Change of Rigidity and Logarithmic Decrement in Different Metals and Alloys at High Temperatures. T. Kikuta. (Tôhoku Univ. Sci. Reports, 10. pp. 139-154, Aug., 1921. Fiftieth report from the Iron and Steel Research Inst.)—In previous investigations difficulties and inaccuracies have arisen in the determination of the logarithmic decrement of metals at temperatures approaching their melting-points owing to the diminution of the number of oscillations, of which the period is to be observed. To overcome this defect, a compound oscillating system is suggested by K. Honda, consisting of a Pt wire, remaining at room temperature, supporting an inertia mass attached on its under side to the test wire, the lower end of which is fixed. The test wire is surrounded by a furnace. The details of the arrangement and method of use are described and illustrated, and formulæ developed for the interpretation of results. The figures obtained for Pb, Zn, Al, Ag, Au, Cu, Ni, steel, Pt, duralumin, 70:30 brass, are tabulated and plotted, and the characteristic features of the curves discussed. In general, rigidity decreases, and logarithmic decrement rapidly increases, with rise of temperature, but the curves are interrupted by a break accompanying a transformation or a change of structure in the metal. A comparison of results from drawn wires and the same after annealing shows that growth of crystal grains is accompanied by increase of rigidity and decrease of logarithmic decrement. A. B. C. L.

438. Increase of Stress near Circular Holes in a Plate in Tension. T. Pöschl. (Zeits. Math. u. Mechanik, 1. pp. 174-180, June, 1921.)—The VOL. XXV.—A.—1922.

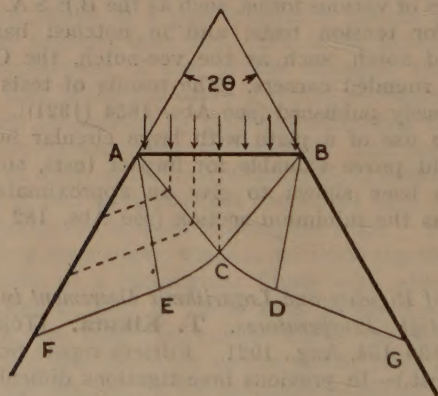
stress distribution in an infinite plate pierced by two circular holes, and subjected to a uniform radial tension. Bipolar orthogonal coordinates given by the equation $x + iy = c \tan \frac{1}{2}(\xi + i\eta)$ are used, the circles being $\eta = \pm \eta_0$. The stress function is:

$$\chi = pc^2 \frac{\cosh \eta + \eta \operatorname{cosech}^2 \eta_0 \sinh \eta}{\cosh \eta + \cos \xi}.$$

The max. values of the stress $\xi\xi$ (hoop-stress) occur at points in the boundaries in the line of centres, of amounts $2p \cosh \eta_0 (\cosh \eta_0 \pm 1)/\sinh^2 \eta_0$, where the + relates to the inner end. This becomes very great if the distance between the circles is small compared to their radii, but for circles small compared with their distance apart ($\eta_0 \rightarrow \infty$), $\xi\xi \rightarrow 2p$, as for a single circular hole. $\xi\xi$ along the line of centres is plotted for various values of η_0 .

W. G. B.

439. *The Resistance to Penetration of Materials, and Ultimate Strength of Wedges.* L. Prandtl. (Zeits. Math. u. Mechanik, 1. pp. 15-20, Feb.,



1921.)—An abridged and simplified version of an earlier paper by the author (Ges. Wiss. Göttingen, Nachr., math.-phys. Kl., p. 74, 1920). Using Mohr's results for the stress conditions determining the plastic state, and neglecting radial variations of stress, the failure of a truncated wedge under pressure applied to the narrow end is found to be as indicated in the diagram. The triangle ABC is pressed in, and the triangles AEF, BDG forced bodily out. The dotted lines are the "stream-lines," and the plastic state is found to exist only in the region above FCG. The crushing stress, f , for the wedge is given by $fff_c = 1 + \theta$, f_c being the crushing stress for the material as usually determined. The ratio AF, AB is also calculated for various cases; for the plane, $\theta = \frac{1}{2}\pi$. The results have an obvious application in the theory of foundations. [See also next Abs.]

W. G. B.

440. *Plastic Deformation of Iron Wedges.* A. Nádaï. (Zeits. Math. u. Mechanik, 1. pp. 20-28, Feb., 1921.)—The deformation and ultimate breakdown of wedges of ingot-iron by pressure applied at the narrow end is studied, and sketches and graphs illustrating the results are given. It is found that the inclined faces are forced out by an amount that is practically constant for some distance down, but which then falls quite

sharply to practically zero, in conformity with Prandtl's theory [see preceding Abs.]. The values of f/f_c , as observed, also agree well with Prandtl's formula. To explain the shape of the region of breakdown in the case of the plane, Michell's theoretical solution for the stresses is quoted.

W. G. B.

441. Forced Vibrations in a System with Varying Frequency, and their Technical Applications. G. Duffing. (Sammlung Vieweg, 6. p. 134, 1918. Abstract in Zeits. Math. u. Mechanik, 1. pp. 72-73, Feb., 1921.)—A study of the differential equation $d^2x/dt^2 + ax + \gamma x^3 = k \sin \omega t$, which approximates to the equation for forced vibrations of a system in which the frequency depends on the amplitude. Assuming a periodic solution, $x = A \sin \omega t$, A is given by a cubic equation, of which one or three of the roots may be real, according to the values of k , ω , and a . Experiments undertaken to test the theory are qualitatively successful, and quantitative agreement to within 10 % was obtained. A short examination of the effects of damping and the inclusion of a term βx^2 is given, and some applications are made.

W. G. B.

442. Repeated-Blow Tests. L. Guillet. (Rev. de Mét. 18. pp. 755-757, Dec., 1921. Paper read before the Assoc. Franco-Belge des Méthodes d'Essais.)—A low-carbon steel bar, 18 mm. in diameter, was annealed at 850° C. and cut into five pieces, one of which was left at its original diameter, while the others were turned down to 17, 16, 15.5, and 15 mm. diameter. They were then all drawn down to 15 mm. In this way an annealed bar, and four bars having undergone different degrees of work, were obtained, all of the same dimensions. On each of these specimens the following tests were carried out: (a) tensile, (b) impact, (c) hardness, (d) repeated blows. It was found that: (1) the tensile test is very markedly effected by even the smallest amount of drawing given, the elongation, in particular, falling considerably. (2) The effect of work is much greater on the elastic limit and the elongation than on the maximum stress. (3) Hardness and maximum stress do not bear a constant relationship to each other. (4) Impact strength is not very much effected. (5) Resistance to repeated blows rises very rapidly as a result of work.

J. L. H.

443. Solution of an Integral Equation occurring in certain Problems of Viscous Fluid Motion. T. H. Havelock. (Phil. Mag. 42. pp. 620-628, Nov., 1921.)—The problems worked out are the fall of a thin material plane in a liquid bounded by two fixed parallel planes, and the motion of a cylinder filled with liquid and acted on by a constant torque. The method of solution of the integral equations arising is more important than the problems solved, and can be applied to cases where the force is variable. The kernel is a series of exponentials, and the solving function is another series of exponentials.

W. G. B.

444. Decay of Oscillation of a Solid Body in a Viscous Fluid. T. H. Havelock. (Phil. Mag. 42. pp. 628-634, Nov., 1921.)—Applies the method of the preceding paper [see preceding Abs.] to the case of a plane oscillating in a fluid between two fixed parallel planes, and the results are discussed in connection with experimental work of Verschaffelt [Abs. 151 (1916)]. The solution in the case of a sphere oscillating inside a fixed concentric sphere is indicated.

W. G. B.

445. *The Problem of Turbulence.* F. Noether. (Zeits. Math. u. Mechanik, 1. pp. 125-138, April, 1921.)—A review of our experimental knowledge of, and of attempts to explain by hydrodynamical theory, the breakdown of stream-line flow in tubes and narrow spaces, for sufficiently large velocities. The facts are first briefly described. There are three main theoretical lines of attack. (1) The investigation of the stability of infinitesimal variations from the steady stream-line state. The conclusion derivable from the work of many mathematicians is that no explanation of the instability of the laminar motion is obtained as far as it can be expressed by linear differential equations, i.e. for infinitesimal disturbances. (2) The method of energy. Reynolds formulated an expression for the rate of change of the energy of the turbulent motion, and he, and others, obtained for special forms of turbulence, quite small Reynolds numbers giving an increase, and so indicating instability. On account of difficulties in the determination of the exact meaning of these results, they can at most be regarded as lower limits of instability; but they point to the necessity of removing the restriction to infinitely small disturbances. (3) Finite disturbance. The inference to be drawn from the above is apparently that, though the laminar motion is theoretically both possible and, in the restricted sense, stable for all velocities, yet the stability resembles that of a ball in a shallow hollow on a hilltop, stable if the disturbance does not exceed a certain limit, but not for greater disturbances. Increase of Reynolds probably decreases the margin of stability. Attempts have been made, notably by the author, to trace the motion starting with a velocity distribution widely differing from the steady laminar one, but no satisfactory result can be recorded. One other significant fact is recorded, that, for a given discharge, the energy is least for a uniform distribution of velocity. Herein lies the possibility of an increase of the energy of turbulence, and the increased resistance to flow is caused by the sharper velocity gradient at the walls. R. v. Mises has also estimated the magnitude of the turbulent motion, and finds, in one example, only a few per cent. of the average velocity.

Reference is made to some associated questions, such as the flow in converging tubes, and Stokes' law for the motion of a sphere.

The references in the footnotes constitute a select bibliography.

W. G. B.

446. *Theory of Aerofoil and Propeller Resistance.* E. Trefftz. (Zeits. Math. u. Mechanik. 1. pp. 206-218, June, 1921.)—A resumé of Prandtl's theory of the cause of the resistance experienced by an aerofoil moving through the air, according to which the air-streams caused by the excess pressure on the underside, and the partial vacuum above the aerofoil, create eddies at the trailing edge, and these necessarily derive their energy from the aerofoil. The theory is very completely described in the paper, and the mathematical treatment is also given, by which the design of the aerofoil which has the smallest value of resistance may be determined under given conditions. Examples are given of the application of the theory to the calculation of the resistance in certain cases. It is also applied to the problem of determining the form of an air-screw having minimum energy loss.

J. W. T. W.

447. *Dispersion of Cannon Balls in falling through Air.* F. C. Brown. (Phys. Rev. 18. pp. 105-106, Aug., 1921. Abstract of paper read before VOL. XXV.—A.—1922.

the Am. Phys. Soc.)—Describes experiments carried out to determine the relative dispersions of smooth and roughened spherical bombs, and a comparison of their performance with that of stream-line bombs. Experiments were made at altitudes of from 1000 to 2700 ft., and in the case of smooth spheres the angle of dispersion was found to average 0.72° . For roughened spheres this angle was approximately halved, but neither form gave nearly as uniform ballistic properties as those obtained with the best stream-line form.

J. W. T. W.

448. *Analytical Symmetry in the Relativity Theories.* A. Buhl. (Comptes Rendus, 173. pp. 829–831, Nov. 7, 1921.)—The notes of P. Painlevé and E. Picard [see Abs. 454 (1922)] have induced the author to publish this paper. Transforming the identity

$$\iint \times dydz = \iiint_v d \times dydz$$

a formula of Stokes' type has been obtained. The determinant leads directly to the form of the Maxwell-Lorentz equations of the electromagnetic field as generalised by De Donder. By substitution in the Stokes form of equation the result is that Christoffel's "hooks" are obtained. In ordinary mathematics these are derived from quadratic forms, but it is possible to proceed in the opposite direction and pass from Christoffel's "hooks" to differential quadratic forms, and it is thus possible to pass from a fundamental identity of the integral calculus, first to the electromagnetic field, and thence to metrical space, which in general is non-Euclidean. It should be noticed, however, that restrictions analogous to those of Picard and Painlevé have to be imposed.

It is possible also by a suitable manipulation of the determinant in the Stokes equation to arrive at the components of the tensor of curvature. The author promises to develop this result in a Memoir, which he expects shortly to publish.

H. N. A.

449. *New Experiments in Gravitation.* C. F. Brush. (Am. Phil. Soc., Proc. 60. 2. pp. 43–61, 1921.)—All atoms are imagined to be continually buffeted in all directions by the ether waves just as are particles of precipitate suspended in turbulent water. Atoms absorb and restore the ether energy, and so each becomes the centre of a field extending in all directions. This is their gravitative field. The first experiment was planned to detect, if possible, any difference between the gravitation field of a large mass of bismuth, which is highly diamagnetic, and those of lead and zinc which are only slightly diamagnetic, and that of tin, which is slightly paramagnetic. The idea is that gravitation and magnetism may have something in common, and that if so, bismuth may show smaller gravitation per gm. than the other metals. A modification of Boys's torsion balance is used, with silver balls as suspended masses. The outer masses of bismuth, zinc, etc., are cylinders, all 4.9 cm. high and 6.1 cm. diam. In all cases the deflections caused by these metal cylinders are divided by the weight of metal causing it, so as to reduce all to a common standard of attraction per kg. The results are: Al, 130; Zn, 100; Sn, 100; Pb, 93; Ag, 80; Bi, 72. The figures given are the nearest whole numbers, the mean of many observations. Thus bismuth, as anticipated, exhibits much the smallest attraction per unit weight.

The author draws the conclusion that relative weight is not always proportional to relative mass in the same locality.

Further experiments on swing pendulums and torsion pendulums, in which the bobs are made of bismuth and other metals, also, in the author's opinion, support the above view. P. E. S.

450. Motion of a Particle in the Field of a Charged Nucleus. K. Ogura. (Comptes Rendus, 173. pp. 348-350, Aug. 8, and pp. 407-408, Aug. 22, 1921.)—Starting with the equations of motion obtained by G. B. Jeffery [Abs. 1802 (1921)] for the case of particle and nucleus being both very small, the author develops some of their results, showing very simply that the principle of the conservation of energy, together with Lagrange's equations and Hamilton's principle, both in generalised form, hold good for such a field. He shows also that the fundamental equations may be written in such manner as to bring out their close correspondence with the equations of classical dynamics. He has also worked out their application to the theory of spectra, following Sommerfeld's line of argument, and states the result obtained by him, reproducing for comparison Sommerfeld's own equation ["Atombau und Spektrallinien," 2nd edition, p. 334]. G. W. DE T.

451. Relativity Motion of Particle Starting with Speed of Light. E. Kasner. (Nature, 108. pp. 434-435, Dec. 1, 1921.)—The Minkowski interval vanishes for uniform motion, $v = c$, so that the length interval between the initial world-point P and any other, Q, is always zero. What is the limit of the ratio, arc PQ/chord PQ, as Q approaches P, as intervals of a particle starting with speed c and having negative acceleration? Using ordinary Euclidean measurements, the limit for real curves is always unity. But the author finds that when arc and chord are measured in terms of the Minkowski or generalised Einstein time-space the limit is $2\sqrt{2}/3 = 0.94$, approximately, while if the initial acceleration is zero, so that the velocity remains that of light for neighbouring points, then the limit may have any value. The author has shown [Amer. Math. Soc., Bull. 20. pp. 524-531, 1914] it is not always unity in the Euclidean plane, but the exceptions there are all imaginary, the slope of the curve at the initial point being necessarily $\sqrt{-1}$. The limit then takes a set of discrete values, 0.94, 0.86, 0.80, 0.74 . . . , the particular one depending on the contact of the curve with the minimal straight line at the given point. If no contact the value is unity, but for contact of order $k - 1$, the value is $2\sqrt{k/(k+1)}$. Both in Euclidean three-space and the Minkowski time-space the limit can take all real and complex values, but in the latter, owing to the minus sign in the interval formula, the exceptions which were imaginary in the Euclidean geometry now become physically real. Particles have been observed to move with speed up to $0.9c$. But the limit remains unity up to speed c , when it would jump from unity to 0.94. The author observes:—"Such a discontinuity is perhaps beyond the possibility of experimentation, but there is no doubt of its theoretical validity." In the general Einstein theory, we have a curved four-manifold in place of a flat one. The formulæ are far more complex, but again there are exceptional values for the limit when the initial speed is c —that is, when the world-line is tangent to a null geodesic on the curved manifold representing the gravitation field.

G. W. DE T.

452. Postulates and Conclusions of the Theory of Relativity. L. T. More. (Phil. Mag. 42. pp. 841-852, Nov., 1921.)—The position of physical science created by the acceptance of the theory of relativity is reviewed from the point of view that, in this theory, we are dealing, not with an abstract, or mathematical analysis, but with a definite conception of what we regard as a real world, whose phenomena are apparent to our sense perceptions. It is argued that the theory of energetics (Kelvin), the theory of electricity as matter, and still more, Einstein's theory, are all doomed to be discarded because they do not postulate matter as a substratum of reality. The principal generalisations of the theory of relativity (quoted from "Relativity," A. Einstein) are critically discussed and reduced to paradoxical conclusions. The well-known example of the train and embankment is quoted, and a simple expedient described by which the length of the train as measured by the observer on the embankment, in spite of his dependence upon light or sound signals, agrees with its length as measured by the observer on the train.

A. B. C. L.

453. Rotating System of Reference in a Minkowski World. II. F. Kottler. (Phys. Zeits. 22. pp. 480-484, Sept. 1, 1921.)—In a previous communication [see Abs. 29 (1922)] the author briefly investigated the inertia field which obtains in a uniformly rotating system of reference, and an expression was found for the appertaining standards of measurement based on Euclidean geometry. It was assumed, firstly, that the system rotated in a Minkowski world, i.e. relative to very distant masses whose gravitational field can be neglected as the special field of the system; secondly, that in the infinitesimal small space-time region the rotation of the system may be replaced by a uniform translation upon which latter the special theory of relativity can be applied. From these two assumptions it follows that local measuring-rods and clocks are known which are valid within such a rotating system, and are termed the natural standards. A rotating observer can construct these everywhere by means of the properties of light. In this previous paper the problem was discussed, whether with the aid of the natural local rods and clocks a unit space-time measurement may be accomplished in the whole rotating system. This was shown to be impossible, and for its solution another set of standards was necessitated. The problem now investigated is whether the rotating observer can be detached from the given space-time measurement. This is shown to be possible when one is free from the prejudice that an infinite number of experiments must precede a measurement. Section 1, deals with time measurement in any accelerated system, and in section 2 the results are applied to the rotating system. It is shown that artificial local clocks must be introduced for non-contradictory measurement in the rotating system, together with the selection of a central clock, and the choice of the shortest paths for the passage of the time-signals. In section 3 a geometrical representation of the results is given. The whole argument, based on simple considerations with respect to the rotating observer, results in the same conclusions as were obtained in the first paper on the basis of the generalised Lorentz transformation.

[Errata: *ibid.*, p. 519, Sept. 15, 1921.] H. H. Ho.

454. Einstein's Theory of Gravitation. J. Chazy. (Comptes Rendus, 173. pp. 905-907, Nov. 14, 1921.)—The paper was communicated by P. VOL. XXV.—A.—1922.

Painlevé, the results arrived at independently in it being the same as those contained in the latter's recent paper [see next Abstract].

The followers of Einstein, as a rule, look for an expression for ds^2 , which does not contain any term of the first degree in dt , and arrive at the expression given in Painlevé's paper, where r does not necessarily mean the distance OM between the gravitating centre O and the movable point M, but an arbitrary function of this distance, which is supposed to be defined independently of the theory of relativity. This function may be written $f(OM)$. When OM increases indefinitely the ds^2 obtained must reduce to the Euclidean ds^2 and the derivative $f'(OM)$, and hence the quotient $f(OM)/OM$ must converge towards unity when OM increases towards infinity. The experimental verifications of the formula for ds^2 hold, not only when $r = OM$, but also, within wide limits, when $r = f(OM)$. If $f'(OM)$ is positive and tends to unity, when OM varies from the sun's radius to infinity, the deviation of light-rays will be $2a/R$, where R is the sun's radius and a the constant in the formula for ds^2 , which is the same value as when r is taken equal to OM. The change in the perihelion of Mercury can be explained with the two preceding hypotheses, provided that $f(OM)$ is very nearly equivalent to OM at the distance of Mercury from the sun. The difference must not produce an alteration in the change of the perihelion greater than that due to errors of measurement, and of calculation from the ordinary planetary theory. If $f(OM)$ is an increasing function, the time of vibration of the atoms will be greater near the sun than at a distance, and solid bodies will contract in the direction of the sun, provided that in the region of displacement $f'(OM)$ is near to unity.

H. N. A.

455. Classical Mechanics and the Theory of Relativity. P. Painlevé. (Comptes Rendus, 173. pp. 677-680, Oct. 24, 1921.)—The whole structure of Newtonian mechanics is based upon the following *axiom of causality*: "It is possible, once for all, and for the whole universe, to define a measure of length, of time, and a trihedron of reference, such that the principal of causality shall be always and everywhere true." The resulting laws no longer hold for an arbitrary system of measurement of space and time. The author believes that Einstein's doctrines will not involve the definite abandonment of the above axiom; that a number of his formulæ will blend with classical science; but that some of the more startling consequences of the theory will not finally survive. In considering the motion of a gravitational element about a gravitational centre, Einstein and his followers implicitly assume that the axes employed are "privileged" axes corresponding to the above axiom, and it is in this way that they arrive at the formula $ds^2 = dt^2(1 + a/r) - r^2(d\theta^2 + \sin^2 \theta d\phi^2) - dr^2/(1 - a/r)$, where a is a constant depending on the mass of the material centre about which the element moves. But this ds^2 is not the only one which answers all the conditions of Einstein's theory. Some of the other formulæ are quite as simple as this, such as $ds^2 = dt^2(1 - a/r) + 2drdt\sqrt{a/r} - d\sigma^2$, where $d\sigma^2 = dr^2 + r^2(d\theta^2 + \sin^2 \theta d\phi^2)$, ds^2 being Euclidean so far as three dimensions are concerned. Now ds^2 has for the followers of Einstein a mystic and universal significance, compelling all phenomena to flow into a sort of space-time form just as water flows into a vase. Thus from the first of the above formulæ they conclude that the vibrations of an atom take place more slowly near the sun than on the earth, the effect being the same for all atoms;

that the solids we regard as invariable, and in particular our measuring-rods, all diminish in the same ratio in the direction of the sun, when they get nearer to that body. These conclusions appear to the author most audacious conjectures, and not inevitable consequences of the theory, which, as Einstein states, would ruin the same if they were shown to be incorrect. The existence of the second formula, and of an infinity of other possible ones, seems to show that this is by no means necessarily the case. With the second formula, when $dt = 0$, we obtain the ordinary Euclidean space, and, reasoning like the followers of Einstein, arrive at the conclusion that solids do not contract in any direction when they approach the sun. Other formulæ, which are quite as simple, lead to the conclusion that these bodies dilate in the direction of the sun instead of contracting; still others that they dilate at right angles to the direction of the sun. The conclusion is that it is pure imagination to pretend to draw consequences of this nature from ds^2 . H. N. A.

456. Note on the Theory of Relativity. E. Picard. (Comptes Rendus, 173. pp. 680-682, Oct. 24, 1921.)—The author preserves an open mind as to the place which the future reserves for the edifice built up by Einstein, but wonders whether it is a progress to try to reduce physics to a mere branch of geometry. He expresses, however, his admiration for the work which has been done in this bold endeavour. The theory contains a number of hypotheses which are more or less hidden. The restricted theory of relativity assumes that the velocity of light, for an observer in a system with a uniform translation, is a universal constant, and uses luminous signals for the measures of time and space; the kinematics of this restricted theory form one of the five portions of Einstein's work. In the general theory the Universe is expressed by a quadratic form of differentials with respect to four coordinates, and it is assumed that every physical law can be expressed by equations which keep the same form when we substitute for the initial coordinates any functions of the same. For any class of phenomena studied it is necessary to make complementary hypotheses to arrive at a corresponding quadratic form. The relation between the restricted theory and the general theory is arrived at by means of the universe at each point which is tangent to the universe considered. Numerous experiments will probably be required to settle the relations between physics and the theory of relativity, and it should be interesting to see if Sagnac's experiment can be explained numerically by means of this theory. [See next Abs.] There are obscure points and insufficiently formulated hypotheses in the theory of relativity, but this is of little importance to those who do not consider that a theory should give an explanation of appearances which agrees with reality, but that it is only necessary that the final formulæ should agree as exactly as possible with the experimental results, the essential part of a theory being the analytical mould in which it encloses phenomena. From this point of view a theory of relativity consists of the quadratic form which corresponds to it. Others are chiefly struck by the paradoxes met with in the theory, and see in it a modification of the fundamental ideas of humanity with regard to space and time, fearing a rupture with common sense. The future will decide how far the new ideas can be incorporated in the common sense of humanity, which Descartes regarded as the foundation of certainty. Without this agreement there can only be scepticism, which is a reef that the theorists of physics have always avoided. H. N. A.

457. *The Theory of Relativity and Sagnac's Experiment.* P. Langevin. (Comptes Rendus, 173. pp. 831-834, Nov. 7, 1921.)—Replying to papers by P. Painlevé and E. Picard [see two preceding Abstracts], the author in the present paper, keeps to the experimental point of view, and recalls that the theory of relativity is the only one which represents the known experimental facts, and which has, in addition, made it possible to predict the deviation of rays of light, and the displacement of the spectral lines in the sun's gravitational field. He then proceeds to consider Sagnac's experiment, which was mentioned in E. Picard's paper, and shows that the result can be explained quantitatively by the generalised theory of relativity. Sagnac caused two rays of light from the same source to interfere with one another, after they had passed in opposite directions round a closed circuit, being reflected by a system of mirrors suitably placed. The platform carrying the optical system was rotated with an angular velocity ω , and a displacement of the interference fringes was produced, corresponding to a difference $4\omega A/c^2$ between the times taken by the two rays to go round the circuit, A being the area inside the circuit projected on a plane normal to the axis of rotation, and c the velocity of light. This is an experiment of the first order (in $\omega R/c$, R being the radius of the platform), and all the theories of optics, mechanical or electromagnetic, and the theory of relativity agree, qualitatively and quantitatively, as to the result. This result can, however, be obtained most simply and naturally by means of the generalised theory of relativity, considering the influence of the gravitational field belonging to observers moving with the platform on the propagation of the rays. This field is the same one which shows itself mechanically by the effects of centrifugal and gyroscopic forces. If x, y, z, t are the space-time coordinates for the moving platform, and x', y', z', t' those for a system of axes with no rotation, it is shown that, from considerations of symmetry, and particularly because the sign of the rotation changes with the position of the observer with respect to the axis of rotation, $z' = z$ and $t' = t$, z and z' being parallel to the axis of rotation. Also $x' = x \cos \omega t - y \sin \omega t$, $y' = x \sin \omega t + y \cos \omega t$. The fundamental invariant, for observers without rotation, has the usual Euclidean form, $ds^2 = c^2 dt'^2 - dl'^2$, $dl'^2 = dx'^2 + dy'^2 + dz'^2$. In the rotating system of reference, substituting, and neglecting terms in ω of order higher than the first, $ds^2 = c^2 dt^2 - 2\omega(xdy - ydx)dt - dl^2$, $dl^2 = dx^2 + dy^2 + dz^2$. The propagation of a ray of light, characterised by the condition $ds^2 = 0$, corresponds to the relation $c^2 dt^2 - 4\omega dA dt - dl^2 = 0$, where $dA = \frac{1}{2}(xdy - ydx)$ represents the surface of the triangle whose apex is the origin, and the base of which is the projection on the plane of x, y of the ray as seen by the observers on the platform.

This can be written, to the same order of approximation, $dt = dl/c + 2\omega/c^3 \cdot dA$; hence by integration round a closed contour $t^2 = l/c - 2\omega A/c^2$, A representing the area of the contour projected on the x, y plane. For the ray which follows the same contour in the opposite direction the area changes its sign, and the time taken is $t_2 = l/c + 2\omega A/c^2$. The difference is therefore $4\omega A/c^2$, which agrees with Sagnac's result. In Einstein's general theory, where the gravitational field is represented by the ten potentials g_{ik} , Sagnac's experiment measures the effect on the propagation of light of the potentials g_{14} and g_{24} , respectively equal to $2\omega y$ and $-2\omega x$, which alone are modified in the first order by the rotation. This optical experiment of the first order is thus related to

Foucault's pendulum experiment, and to that with the gyroscope, which make it possible to show the rotation of a material system by means of experiments made inside it. H. N. A.

458. The Curvature of Light-Rays in a Gravitational Field. K. Ogura. (Comptes Rendus, 173. pp. 641-644, Oct. 17, 1921.)—In the equation $ds^2 = f^2 dt^2 - d\sigma^2 = f^2 dt^2 - H_1^2 dx_1^2 - H_2^2 dx_2^2 - H_3^2 dx_3^2$, for a static field *in vacuo*, the functions f , H_1 , H_2 , and H_3 do not depend on t ; the resulting equation for light-rays is given. From this, using Frenet's formula for the Riemann space, as explained by W. Blaschke (Math. Zeitschrift, vol. 6, p. 94, 1920), and neglecting torsion, the following expression for the curvature of the light-ray is obtained:

$$\frac{1}{\rho^2} = \frac{1}{H_1^2} \left(\frac{1}{f} \frac{\partial f}{\partial x_1} \right)^2 + \frac{1}{H_2^2} \left(\frac{1}{f} \frac{\partial f}{\partial x_2} \right)^2 + \frac{1}{H_3^2} \left(\frac{1}{f} \frac{\partial f}{\partial x_3} \right)^2 - \left(\frac{1}{f} \frac{\partial f}{\partial \sigma} \right)^2.$$

Using Lamé's differential parameter of the first order, this may be written in the following form, which is independent of the choice of coordinates: $1/\rho^2 = (\partial \log f / \partial n)^2 - (d \log f / d\sigma)^2$, where $\partial \log f / \partial n$ is the derivative of $\log f$ along the normal to the surface $\log f = \text{const.}$ It follows that $(1/\rho)^2_{\text{min.}} = 0$ along the normal to the surface $f = \text{const.}$, and $(1/\rho)^2_{\text{max.}} = (\partial \log f / \partial n)^2$ along all tangents to this surface. It is shown that the curved rays satisfy Monge's equation, and form a system of *smooth* curves in the generalised sense. On the parametric surfaces, for example, on $x_3 = \text{const.}$, we have a system of smooth curves of the kind called by G. Scheffers "Kurvennetz ohne Umwege." H. N. A.

459. Effect of Sun and Moon on the Centrifugal Field of the Earth. A. Kopff. (Phys. Zeits. 22. pp. 309-310, May 15, 1921.)—A short mathematical treatment based on Einstein's theory leads to the conclusion that the effect of the sun and the moon on the centrifugal field of the earth is much too small to permit of measurement [see Abs. 449 (1918) and 1367 (1921)]. A. W.

460. Logical Basis of the Generalised Theory of Relativity. A. Schildlof. (Arch. des Sciences, 3. pp. 471-487, Sept.-Oct., and pp. 569-583, Nov.-Dec., 1921).

461. Ether and Relativity. E. Wiechert. (Phys. Zeits. 23. pp. 25-28; Disc., 28, Jan. 1, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The present paper deals with a known experimental line of thought which the author terms an investigation of the various space-time ways, or, more frequently, the clock paradox of the relativity theory. From the Lorentz theory and its development by Einstein, the validity of the Lorentz transformation is assumed. The author then concludes that by changing the state of motion of a physical system, every dimensional alteration of the body and of the process velocities will take place as prescribed by the Lorentz transformation. The present paper is concerned with the significance of those phenomena which are regarded as given. The experimental field chosen is the space between the stars and the measuring-rod is taken so great that the bodies of the physical system investigated can be regarded as points. It is then established that every change in the state of motion produces a change in the state

of a body in the world under consideration. The author discusses the two physical ideas of relativity, namely, body relativity and standpoint relativity. The paper is philosophical throughout. H. H. Ho.

462. Accuracy of the Fall and Rise Experiments. E. Schmid. (Phys. Zeits. 22. pp. 438-441, Aug. 1, 1921.)—From a series of time experiments for the fall or rise over the same distance l , the average velocity and the constant of the Brownian movement (i.e. the average square of the displacement per sec.) are determined according to the formula $v = l/(1/n)\sum t_i$, and $\lambda^2 = l^2[(1/n)\sum(1/t_i) - 1/\{(1/n)\sum t_i\}]$. Schrödinger [see Abs. 10 (1916)] has deduced the following expressions for evaluating the average error accompanying the formulæ above, namely, $\mu(v)/v = \lambda\sqrt{\{(1 + 3\lambda^2)/lvn\}}/\sqrt{(lvn)}$, and $\mu(\lambda^2)/\lambda^2 = \sqrt{(2n - 1)/n}$. The object of the present paper is to investigate the problem mathematically for the purpose of comparing the results of theory and experiment. The author also takes the opportunity of correcting a formula for the average error previously derived by him on the basis of the Fletcher method [see Abs. 41 (1922)]. Good agreement is found between theory and experiment. H. H. Ho.

463. Density of Packing and Fall Velocity of Lycopodium. A. Ilgner. (Phys. Zeits. 22. pp. 370-375, July 1, 1921. Extract from Dissertation, Giessen.)—The author first considers the experimental work of Keehan and Zeleny on the fall velocity of small bodies in air, the data of which were compared with the theoretical values based on the Stokes formula. These authors found the observed values of the final velocity to be much smaller than those calculated. With artificial spheres, however, made of black wax, mercury, or paraffin, it was found within wide limits for spherical dimensions that the fall-velocity values were in good agreement with the theoretical data. The present paper is devoted to an investigation into the cause of the above divergence for lycopodium. Section I deals with the density of packing of spherical bodies. The following results were obtained:—The air volume, in general, decreases with the spherical dimensions, since with decreasing spheres the space between wall and spheres becomes very small. The pore volume depends very much on the form of the containing vessel, and the minimum is obtained with round walls as in cylinders and spheres. The pore volume decreases with increasing dimensions of the container, and also decreases after shaking, although the latter decrease rapidly assumes asymptotically a constant value. If the pore volume be taken as ordinate and the sphere dimension as abscissa, then the curve does not show a uniform descent, but fluctuates very markedly. Only with spherical containers is an approximately uniform curve obtained. Pure packing of single spheres never occurs, since irregularities in orientation continually appear. If the friction within the packing be increased, as, for example, by coating the spheres with thin shellac, then the air volume increases. In the use of lycopodium, the limiting value of the pore volume must be found when the spherical radius is continuously decreased. Section II investigates the fall velocity of lycopodium. The density of the lycopodium was determined by means of a sensitive volumenometer. The section gives a sketch of the experimental details employed, together with references to corresponding work by other workers. The discrepancy in the case of lycopodium between the theoretical and calculated values is found to be due to the surfaces of the spores, which are covered with a network

of fine prominences; these cause the motion to involve a greater air volume than is necessitated by the mass alone. This conception received confirmation by the experimental work on the packing density, which, for lycopodium spores, was much too small owing to the larger air volume necessitated. If the *apparent* external radius be utilised in the friction term of the Stokes formula, and the *true* density and inner radius in the weight term, then correct values for the fall velocity are obtained.

H. H. Ho.

464. Method of Determining the Distribution of Pore Sizes in Porous Material. **E. W. Washburn.** (Nat. Acad. Sci., Proc. 7. pp. 115-116, April, 1921.)—A method for determining the effective pore diameters in a porous material, such as charcoal, can be based upon the expression for the pressure, p , required to force mercury into a capillary pore of radius r , namely: $p = -2\gamma \cos \theta / r$, where γ is the surface tension and θ the angle of contact. The fraction of the total porosity which is due to pores of effective diameters lying between any two stated limits is found by means of pressure and volume measurements on the material exposed to mercury in a previously exhausted bomb. The value of θ can be determined from an X-ray photograph of the Hg meniscus, or by the drop-shape method.

L. H. W.

465. The Cohesion Force in the Diamond. Addendum. **A. Landé.** (Zeits. f. Physik, 6. 1. pp. 10-11, 1921.)—The compressibility of the diamond, found by L. H. Adams [Abs. 1187 (1921)], namely 0.16×10^{-12} , is much more trustworthy than the value of T. W. Richards, 0.5×10^{-12} , and is in much better agreement with the calculated values of Einstein, Lindemann, Debye, and Grüneisen, 0.10, 0.13, 0.16, 0.11. Moreover, Fuchs and Madelung have found 0.38 for corundum, and 0.43 for sapphire, all smaller figures than Richards's. The diamond should have a very low compressibility, and the figure 0.16 further brings the values of n and m in the formula for the lattice potential [Abs. 1684 (1921)] down to 5 and 7, whilst 0.5 would yield impossible values. The author does not claim, however, that the details of his atomic model will stand; modification will be required.

H. B.

466. Passage of Moving Molecules through Heterogeneous Fields of Force. **H. Kallmann and F. Reiche.** (Zeits. f. Physik, 6. 5 and 6. pp. 352-375, 1921.)—A mathematical paper not permitting of concise abstraction.

A. B. W.

467. Forces within a Static Atom. **I. Langmuir.** (Phys. Rev. 18. p. 104, Aug., 1921. Paper read before the Am. Phys. Soc.)—If in addition to the Coulomb forces between charged particles we assume the existence of another force (quantum force) equal to $F_q = 1/mr^3 \cdot (nh/2\pi)^2$ acting between an electron and a nucleus, we find that a stationary electron is in stable equilibrium when its distance r from a nucleus is the same as the radius of a circular orbit corresponding to a stationary state in Bohr's theory. The total energy of the electron is also the same as that given by Bohr's theory. The frequency of oscillation about the position of equilibrium is identical with the frequency of revolution of the electron in the Bohr atom. Thus the Rydberg constant and the Balmer series can be deduced from this law of force without assuming moving electrons.

It seems possible to construct satisfactory models of the helium atom and the hydrogen molecule on this basis by assuming that each electron acts towards the nucleus like a dipole acting on a charge while the quantum action between electrons is like that between dipoles. Thus the forces depend on the orientation of the electrons as well as on their distance. This view suggests that quantum relationships may have their origin in the structure of the electrons and each change in the quantum number associated with an electron corresponds to a change in the structure of the electron.

AUTHOR.

468. *The Magnitudes of Atoms.* T. W. Richards. (Am. Chem. Soc., J. 43. pp. 1584-1591, July, 1921.)—It is pointed out that the contraction suffered during combination, taken in connection with the compressibilities of the elements combined, makes possible an approximate estimate of the bulk occupied by the several constituents in a compound. Calculations are made for the diameters of the atoms of the halogen and the alkali metals, which diameters are found to lie about half-way between the results of Bragg and those of Landé.

Emphasis is placed upon the importance of considering the compressing effect of the affinities concerned, in making any comparison of atomic volume.

AUTHOR.

469. *The Circumnuclear Lagrange Function of the Bohr Atom.* M. Brillouin. (Comptes Rendus, 173. pp. 639-641, Oct. 17, 1921.)—Continuing the discussion commenced in a previous paper [see Abs. 1685 (1921)], the author arrives at equations for the angular velocities of the electrons and for the energy. From these can be obtained the privileged ellipses of Bohr-Sommerfeld, given by $u = 2m\pi$, $v = 2n\pi$, $C_1 = \frac{2km\pi}{C}$

$= \frac{mk}{2\pi}$, $C_2 = \frac{C^2 k^2}{8n^2 \pi^2} = \frac{2\pi^2 k^4}{n^2 k^2}$, taking even multiples of π for stable orbits.

More or less unstable privileged orbits are arrived at by taking for u or v , or for both, uneven multiples of π . The orbits of a hyperbolic nature ($C_2 < 0$) have very complicated forms; a method of dealing with such orbits is suggested in the original paper, but the author recognises that it does not appear very easy to carry it out. He hopes, however, that it may yield important results.

H. N. A.

470. *Atomic Structure.* A. Dauvillier. (Comptes Rendus, 173. pp. 1077-1079, Nov. 28, 1921.)—In a previous paper [Abs. 322 (1922)] numerical results were given relative to the electronic structure of heavy atoms. These figures enable a determination to be made of the limits of ultra-violet and X-ray absorption for these elements [see Abs. 1995 (1921)]. The disappearance of certain lines of the characteristic X-ray spectra, and the variation of intensity of other lines, confirms largely the theory of electronic structure of the elements which is here presented schematically in tabular form. In this table it is to be noted that chemical similarity depends not only on the number of superficial electrons but also on the underlying electronic layer. The table allows of the prediction of the transformations observed in the X-ray spectra of the lighter elements. Thus the lines Ma , $M\beta$, $L\gamma_6$ and $L\beta'_7$ diminish progressively and disappear for cerium. In the same way that the lines

$M\delta$, β_5 , and γ_2 vary in intensity in the group W-Pt, the lines $M-\gamma$, β'_2 , β'_2 , β_2 , γ_1 , γ_9 undergo similar variations in the group Mo-Pd, and the lines M_1 , M'_1 , M_2 in the group Cr-Ni.

A. W.

471. Crystal Structure of Titanium, Zirconium, Cerium, Thorium, and Osmium. A. W. Hull. (Phys. Rev. 18. pp. 88-89, Aug., 1921.)—X-ray powder diffraction patterns of these metals have been obtained in the manner previously described [see Abs. 380 (1918)], using a molybdenum water-cooled X-ray tube, with zirconium filter. The positions of the lines in the patterns were measured on a slide-rule, and the corresponding planar spacings calculated by the Bragg formula.

Titanium.—Slightly distorted form of "hexagonal close packing" of solid spheres, being shortened in the direction of the principal axis in the ratio 1.633 : 1.59. The side of the unit triangular prism is 2.97 Å., and its height 4.72 Å.U. The lattice is made up of two sets of these prisms, the atoms of one set being in the centre of the prisms of the other set.

Zirconium has a crystal structure identical with titanium, with axial ratio also 1.59. The side of its unit triangle is 3.23 Å., and its height 5.14 Å.U.

Cerium shows the same structure as Ti and Zr, with axial ratio 1.62. The side of the unit triangle is 3.65 Å.U., and height 5.96 Å.U.

Thorium is a face-centred cubic lattice with side of cube 5.04 Å.U.

Osmium crystallises in a hexagonal close-packed lattice, with axial ratio 1.59. The side of its unit triangle is 2.714 Å.U., and its height 4.32 Å.U.

This analysis completes the eighth group of metals. The results are briefly summarised as follows:—

The second and third elements of each row, namely Cq, Ni, Rb, Pd, Ir, Pt, are *face-centred cubic arrangements*. The first members, Fe, Ru, and Os, are different from the rest. Fe is a *body-centred cubic*; Ru and Os are *hexagonal close-packing arrangements of oblate spheroids*, the axial ratio of each being 1.59 [see Abs. 1093 (1921)].

A. B. W.

472. Determination of Surface Tension from the Rise in Capillary Tubes. S. Sugden. (Chem. Soc., J. 119. pp. 1483-1492, Sept., 1921.)—The applicability and limitations of previously developed formulæ are discussed and a general theory of the rise of liquids in tubes of any diameter is given, from which a table of corrections is constructed rendering possible the use of tubes of any diameter for the measurement of surface tension by the method of capillary rise. A simple apparatus, of which the essential feature is the use of two thin-walled tubes mounted close together so that both menisci can be seen at once in the field of view of a small reading-microscope, is described, which has the special advantage that only small amounts of the liquid to be tested are required. The results obtained are tabulated for water and benzene, the means being: Water (against air at 20° C.), $\gamma = 72.70$ dynes/cm.; benzene (against air at 20° C.), $\gamma = 28.85$ dynes/cm.

A. B. C. L.

473. Colour of the Light from the Night Sky. Rayleigh. (Roy. Soc., Proc. 99. pp. 10-18, April 6, 1921.)—The experimental method employed is that of exposing a photographic plate partly under coloured screens,

each designed to transmit a limited portion of the spectrum, and, at the same time, partly under a neutral-tinted photometric wedge of carbon in gelatine, graduated to indicate the proportion of the incident light transmitted. The plate is then developed and the photographic intensity under each screen matched, by a photoelectric method, with that under some portion of the wedge. The scale reading at this point indicates the proportion of the total photographic effect of the incident light due to that transmitted by the particular screen in question. In this way observations have been made of the light from a starlight sky and from the blue sky at sunset and near midday; also of direct sunlight and moonlight.

It is found that the light from the night sky is of the same quality as direct sunlight or moonlight, but is much yellower than the clear day sky. These results were confirmed by a visual method [see also Abs. 42 (1921)]. This difference between the quality of the light from the night sky and the day sky contradicts the theory that the former is sunlight scattered by a rare outer atmosphere, and a comparative absence of polarisation, determined on a previous occasion, confirms this. The light may originate from an unresolved background of stars, or, as held by van Rhijn, it may be sunlight scattered by meteoric substance. It cannot be attributed, in the main, to the green aurora line.

Colour of Moonlight.—One observation each has been secured of the quality of sunlight diffusely reflected from a fresh and a weathered specimen of basalt, a terrestrial volcanic rock. That from the fresh surface is of the same chromatic character as moonlight or sunlight, but the light from the other specimen is yellower. This points to absence of weathering of the volcanic rocks of the moon, in agreement with the absence of a lunar atmosphere. M. A. G.

474. Vertical Thermal Gradient in the Atmosphere. L. de Marchi. (Accad. Lincei, Atti, 30. i. pp. 269 272, May 2, 1921.)—Discusses the conditions of density and pressure existing between the mass in vertical motion and the surrounding atmosphere. Referring to the conclusions of former investigators, which implicitly admit the condition of reversibility and necessitate the supposition that equilibrium is instantaneously established between the ascending column and the external air at the same level, the author says that complete equilibrium is never established, especially in the case of a very extensive vertical motion, because before it can be verified the unit of mass under consideration has reached a different level. This is proved by the continuous deformation of the isobaric surfaces in and around an ascending or descending current, whereas according to the hypothesis of instantaneous equilibrium the baric situation should remain unchanged. But if inequality of pressure be maintained between the vertical current and the surrounding air there is also a continuous exchange of air, and therefore of motion and energy, between the exterior and the interior or vice versa. Lateral exchanges of quantity of motion between contiguous streams are caused in moving liquids by turbulence, which represents an enormous loss of mechanical energy transformed into heat. We must admit a like effect in the air, especially in the strata near the earth. The equations of equilibrium leave this out of account. If a vertical motion sufficiently powerful to cause by centrifugal force a projection of air outwards be formed around an ascending column, the gradient may rise above the normal. These

conditions may be caused by waterspouts. Irregularities in the vertical distribution of temperature may be explained by the fact that convective movements cannot be considered adiabatic nor, strictly speaking, reversible, so that the equations from which the normal gradient was deduced are not legitimately applicable.

E. F.

475. *Thermal Gradient and Vertical Acceleration in the Atmosphere.*

L. de Marchi. (Accad. Lincei, Atti, 30. i. pp. 367-371, June 19, 1921.)

—Measures of vertical velocity obtained by pilot balloons do not permit of an accurate estimate of the actual acceleration at all points of the vertical, but give only approximate values of the average acceleration for distances of 100 to 150 or more metres. There can be no doubt that sudden jumps of vertical velocity occur in the atmosphere corresponding to the more or less turbulent motion of the air. A rapid ascending current tends to slow down owing to the inertia of the overlying strata, in which an effective downward baric gradient is generated by compression, with a corresponding diminution of the thermal gradient. An upward acceleration is determined when a certain quantity of vapour is condensed at a certain altitude, as occurs in the case of supersaturated air. The sudden generation of heat causes rapid expansion of the condensing stratum and increase of internal tension, but equilibrium with the external pressure is quickly established. As the extent to which the vapour in an ascending current may become supersaturated cannot be verified, the weight of vapour condensed for a unit of weight of the air can be calculated only indirectly. After treating the problem mathematically, the author goes on to say that the accelerations thus generated do not sensibly affect the vertical thermal gradient. It is, however, otherwise with the slowing down caused rapidly, sometimes abruptly, by the inertia of the overlying strata. These, before the arrival of the ascending column, are compressed and projected upwards beyond the limit of condensation of the vapour they contain. This compression generates a downward vertical gradient, which retards and abruptly arrests the underlying upward motion, with a corresponding negative acceleration which may reach several metres per second. This would cause a sudden lowering of the vertical thermal gradient and perhaps also the inversion of temperature often observed above the clouds.

E. F.

476. *Evaporation from Extensive Water Surfaces.* **E. Kleinschmidt.**

(Meteorolog. Zeits. 38. pp. 205-209, July, 1921.)—W. Schmidt (Ann. d. Hydrographie, 1915) has estimated the mean annual evaporation from the oceans by considering the quantities of heat transferred annually to and from the surface. If K represents heat transferred by convection, V that rendered latent by evaporation, and W the net income by radiation to and from the surface, then $K + V = W$, provided the oceans are considered as a whole, and the period is a complete year. W may be obtained approximately from present data concerning radiation, but K is unknown. However, by making certain assumptions, in particular that the sea is throughout warmer than the air, so that the flux of heat by convection is from water to air (K positive), Schmidt was able to calculate the ratio K/V , and knowing W , i.e. $K + V$, was able to deduce V , and thence the evaporation. This was found to be 760 mm. per year. Applying Schmidt's method to Lake Constance, Kleinschmidt finds that it gives a value of the annual evaporation much less than is known otherwise to be the

case, and accordingly he undertakes a critical examination of Schmidt's assumptions. He raises objections to Schmidt's procedure in regard to the ratio K/V , concluding that it leads to a value of K which is considerably too large, though, for the open oceans, of the right sign, and consequently to a value of the evaporation which is too small. Taking the extreme value $K = 0$, an upper limit is placed to the mean annual evaporation from the oceans, namely 1060 mm., and reasons are given to support 900 mm. as a lower limit. Wüst's recent estimate is 820 mm. (*ibid.*, June, 1921). In the particular case of Lake Constance the failure is seen to be mainly due to the fact that the flux of heat from water to air only holds in the winter, and that, the whole year considered, K is negative.

A note is added in which Schmidt points out that for reasons such as the last, his method must admittedly be confined to the oceans to which he holds it to be applicable. He cites Wüst's value as confirming his own.

M. A. G.

477. *Depth of Glaciers.* C. Somigliana. (Accad. Lincei, Atti, 30. i. pp. 291-296, May 8; 323-327, June 3; and pp. 360-364, June 19; ii. pp. 3-7, July, 1921.)—Boring operations for ascertaining the depth of a glacier being so laborious, and nowadays so costly, as to be practically impossible, the idea has occurred that the same result might be achieved indirectly by means of some element more accessible to measurement. Such an element has been found in the superficial velocity. The various strata of ice glide, under the action of gravity, one over the other, so that the relative velocities are added together, and it may be said generally that the velocity is maximum on the surface and minimum at the bottom. But we cannot admit with W. Werenskiöld that the superficial velocity at a given point depends exclusively on the depth at that point, and that these two elements are therefore simply deducible one from the other. The question may be put on a broader basis by trying to connect the superficial velocity of all the points of the section of the glacier with the curve of the profile of the section. This is the problem which is here presented for the first time, and which admits of a perfect and very simple solution. Thus, within the limits of the validity of the theory, it is possible to make an accurate plan of the profile of a section by merely knowing the superficial velocity of the points of that section. The rest of the paper is devoted to the mathematical treatment of the problem.

E. F.

478. *Latitude Variation at U.S. Naval Observatory.* F. B. Littell. (Astron. J. 33. pp. 173-177, Aug. 5, 1921.)—This gives the continuation for 1920 of the work previously reported [see Abs. 791 (1921)]. For this year the deduced value of the constant of aberration is $20''.449$, but the probable error of latitude from a single observation is rather larger than in any of the four years included in the previous paper.

A comparison is included between the Washington values and those deduced by Wanach from the International observatories, giving strong indications of the z -term, omitted by Wanach.

W. W. B.

479. *The Einstein Tower.* (Observatory, 44. pp. 372-373, Dec., 1921.)—In honour of Prof. Einstein a tower-telescope has been erected at the Potsdam Astrophysical Observatory. Essentially it will be a fixed

vertical telescope, of 60-cm. aperture, and 14.5 m. focal length. The spectrographs are underground at constant temperature, one being a plane grating of 12.5 cm. aperture and the other a prism spectroscope with very large prisms, which will give a dispersion of 2 Å. per mm. for the brightest stars. It will be used for astrophysical research, but specially for the Einstein shift of spectral lines in the sun and stars.

W. W. B.

480. *Displacement towards the Red in the Solar Spectrum.* **F. A. Schulze.** (Zeits. f. Physik, 5. 5 and 6. pp. 371-373, 1921.)—This paper discusses the "probability" of systematic errors affecting such results as Grebe obtained [Abs. 617 (1921)] for the displacement towards the red of lines in the solar spectrum. Five different probability functions are considered, and it is seen that the probability is very much in favour of the validity of Einstein's theory. **A. W.**

481. *Displacement towards the Red of the Spectral Lines of Stars.* **O. Kohl.** (Phys. Zeits. 24. pp. 665-673, Dec. 15, 1921.)—A discussion of the Einstein gravitational effect leads to the conclusion that it may be possible to determine the magnitude of the effect by observations on the stars of the Taurus group. [See Abs. 1171 (1920).] **A. W.**

482. *Stability by Poisson's Criterion in the Problem of Three Bodies.* **J. Chazy.** (Comptes Rendus, 173. pp. 517-519, Sept. 26, 1921.)—The author considers the possibility of orbits remaining stable, even after the time has become infinite. He shows that if in this extension the radius vector has real values, the time must necessarily be imaginary. He interprets this for motion along a hyperbola, transferring through infinity from one branch to another. He states that there are an infinite number of analytical extensions of the hyperbolic motion of two bodies, in which the Cartesian coordinates are real but the times imaginary. Extending to three bodies, trajectories which are not exceptional must either (1) possess Poisson-stability when the time is not infinite, or (2) they cannot be extended in real curves. The limiting shape of the triangle of the three bodies cannot be quite arbitrary, but must be one or other of the two figures of relative equilibrium given by Euler and Lagrange. In the particular case chosen by Poincaré, when two of the bodies are near each other and the third infinitely remote, the author says the motion cannot be extended along a real curve whether the time be imaginary or not, neither can they be stable without being extended beyond infinity. **W. W. B.**

483. *Stability in Problem of Three Bodies.* **J. Chazy.** (Comptes Rendus, 173. pp. 576-578, Oct. 10, 1921.)—If the constant of *vis viva* is positive, then for an infinite increase of time either (1) all these mutual distances are infinite of first order (called hyperbolic motion), or (2) two are infinite and one finite, involving 12 oscillating elements, 6 hyperbolic and 6 elliptic (called hyperbolic-elliptic motion), distinguishing between the three cases according to which of the three bodies is at an infinite distance from the other two, or (3) a limiting case of (2), when two distances are infinite of first order and the third infinity of $\frac{2}{3}$ order. In all these cases the motion is unstable, but not arbitrarily unstable.

If the constant of *vis viva* is zero the motion is in general hyperbolic—**VOL. XXV.—A.—1922.**

elliptic, and there are for each curve limiting values of the ratios of the three mutual distances. If the constant of *vis viva* is negative, there are three cases. (1) Two mutual distances infinite and the third finite (hyperbolic-elliptic). (2) All three distances remain finite when time is infinite, as in elliptic motion of two bodies, or in periodic solutions of the problem of three bodies. (3) Distances sometimes finite and sometimes infinite for one of the bodies.

The author announces a theorem dealing with trajectories in space of 12 dimensions, and concludes from it that if the constant of *vis viva* is negative the hyperbolic-elliptic trajectories are as numerous as the others if two of the masses are zero, but less numerous if none of them is zero. He enunciates a further theorem dealing with oscillations in the mutual distances.

W. W. B.

484. Periodic Motions of a Heavy Solid Body approximating to Regular Precessions. I. Avenanti. (N. Cimento, 22. pp. 303-320, Nov.-Dec., 1921.)—Given a heavy solid body rotating about a fixed point O. To study its motion let there be three fixed axes $O(x', y', z')$, of which the axis Oz' is supposed to be vertical. Let there be also three movable axes $O(\xi, \eta, \zeta)$, rigidly attached to the body, with the special proviso that these three axes be the principal axes of inertia relatively to the point O.

The treatment of the problem is entirely mathematical, and does not lend itself to condensation.

E. F.

485. Gravity and Radiation-Pressure. H. Groot. (K. Akad. Amsterdam, Proc. 24. 1. 2 and 3. pp. 64-71, 1921.)—The author summarises the investigations into radiation-pressure, since it was shown experimentally by Lebedew in 1910, especially that of Eddington and Jeans [see Abs. 1258 (1917)], but states that no estimation of the extent of the possible effect has been made hitherto. Since qualitative results alone are liable to be totally misleading, he considers three phases of the problem quantitatively. (1) Nebula surrounded by stars. In this case he concludes that the attraction of the stellar system on a nebula is not appreciably modified by pressure of radiation, which cannot explain deviations from the Newtonian law in such a case. (2) Planet (absorbing body) near a nebula, whose radiation-pressure may affect the planet. His conclusion is that on account of the uncertainty which prevails in regard to the quantity of energy emitted by the nebula, it is difficult to make an accurate estimation of the amount by which the attraction of the mother-nebula on a newly separated planet must be diminished in virtue of radiation-pressure. Since both planet and nebula are contracting the effect will be diminishing, and in general will have been greater for the larger and more distant planets. For these large planets the diminution of gravity due to radiation-pressure may have been appreciable. Any peculiarities in the solar system that can be explained by such a change of gravitation are, he thinks, probably due to this cause. (3) Radiation-pressure between different parts of the same nebula. In this case he concludes that there is every reason to expect that in nebulae with some condensation nuclei the gravitation of the different parts on each other has greatly diminished, if it is not quite exceeded by the mutual radiation-pressure. This refers only to internal gravitation, external being unaffected.

W. W. B.

486. Annual Term in Right Ascensions. M. L. Zimmer. (Astron. J. 33. pp. 201–202, Sept. 28, 1921.)—In a previous paper [Abs. 678 (1920)] the author established an apparent difference of 0.04 or 0.05 sec. between clock corrections determined near sunset and those near sunrise. Observations of 6-hour and 18-hour groups during 1920 show that the curve of corrections is continuous and shows no steep gradient at sunrise or sunset such as would be expected if the cause were lateral refraction due to unequal expansion of air to east and west. Other observers have obtained results confirming this. The author points to the fact that certain stars persistently give much larger differences than others, which he considers eliminates not only lateral refraction but also varying personal equation, diurnal variation of clock rate, or irregular rotation of the earth, which would affect all stars alike. Washington and Greenwich observations of the moon and observations of Uranus and Neptune are also quoted in support of the author's tentative conclusion that the cause of the difference is not terrestrial, but stellar, and he urges the importance of increasing the amount of data available by means of extra observations of the moon and outer planets about six hours on either side of the sun.

W. W. B.

487. Atomic Energy and Solar Radiation: Sunspots and Aurora. F. H. Loring. (Chem. News, 122. pp. 277–279, June 17, 1921.)—The author quotes Humboldt's description of the aurora, and sketches the progress made in its investigation by De la Rive, Sabine, Birkeland, Störmer, and others, and then suggests the direct connection with sunspots illustrated by the double spot of 1921 May with its accompanying magnetic disturbances and aurora. To the previous suggestion that atomic nuclei and electrons are ejected by pressure from the interior of the sun, the further suggestion is added that some of these escape through rifts in the solar envelope (sun-spots), and reach the earth's atmosphere, producing auroral manifestations.

W. W. B.

488. Rotation Period of the Sun. P. Fox. (Yerkes Observat. Publ. 3. 3. pp. 67–203, 1921.)—The author has measured 3777 points on the Ca flocculi to obtain diurnal motions (ξ) and periods (P) in mean solar days at various heliographic latitudes (ϕ).

Number.	ϕ .	ξ .	P.
	°	°	°
267	2.78	14.56	24.72
540	7.80	14.51	24.81
842	12.56	14.38	25.03
1044	17.49	14.30	25.17
664	22.20	14.12	25.50
274	27.17	13.98	25.75
107	32.03	13.75	26.18
39	37.32	13.43	26.81

To fit these he obtains a formula $\xi = 11^{\circ}.584 + 2^{\circ}.976 \cos^2 \phi$. Higher velocities are shown in the southern hemisphere. Later years in the series seem to show rather slower velocities, but he does not consider

a variation of rate as proved. He finds differential motion of the flocculi about the spots, anti-cyclonic about single spots and about the following numbers of bipolar spots, cyclonic about the preceding numbers. Comparison of mean results by various methods, i.e. using different layers; such as deep spots, shallow spots, etc., show that there is progressive increase of velocity with ascent in the solar atmosphere. He gives figures for areas covered by flocculi. Usually the zone of maximum is the same for flocculi and for spots, and moves progressively towards the equator.

Measurements were made on a ruled globe, on which the spectroheliograms were projected, and the positions of sun-spots are in fair agreement with Greenwich photoheliographic results, which he regards as evidence that the globe method is as good as the older micrometer methods.

W. W. B.

489. *Graphic Representation of Filaments in the Upper Layer of Solar Chromosphere.* d'Azambuja. (*Comptes Rendus*, 173. pp. 1450-1452, Dec. 27, 1921.)—Deslandres and the author began in 1913 at Meudon to plot the filaments throughout a solar rotation, just as is done at Zürich with the spots. After the war's interruption the work was resumed; and a specimen is given of the result for rotation 881 of the Greenwich series (July 30 to Aug. 25, 1919) on a plane projection, the motion of each of the filaments being also indicated by means of arrows. To this general view must be added detailed movements and modifications which cannot be shown in the single graph, but are given in tables. The maximum of filaments appears to fall three years later than that of sun-spots. Twenty per cent. of the filaments show a general drift, the rest being practically motionless. More work is necessary to provide an explanation, and the author proposes to cover at least a whole sun-spot period with this object.

W. W. B.

490. *Systematic Photographic Chart of the Moon.* C. Le Morvan. (*Comptes Rendus*, 173. pp. 633-635, Oct. 17, 1921.)—The first part of this work appeared in 1914, dealing with phases from new to full moon. This second part deals with the phases from full to new moon, the whole comprising 48 sections, 38 cm. $\times$ 49 cm., selected from photographs obtained in the focus of the great equatorial coude of the Paris Observatory. The phases near new moon, being perforce photographed in the early morning, have suffered more than those in the previous part of the work from atmospheric disturbances. The mean diameter of the moon's image on the photographs is 1.04 m., but it is impossible wholly to avoid discrepancies due to parallax, refraction, libration, etc. The author is sceptical in regard to changes said to have been observed on the moon's surface, and attributes them mainly to the varying angle of illumination from the sun, and to the earth's variable atmosphere. He considers that this atlas and that of Lœwy and Puiseux will provide dated reference standards for any doubtful cases of change.

W. W. B.

491. *Photometric Study of Lunar Eclipse of Oct. 16-17, 1921.* A. Danjon. (*Comptes Rendus*, 173. pp. 706-708, Oct. 24, 1921.)—The photometer employed enabled direct comparison between the limb furthest into the shadow and the opposite limb by means of a Wollaston double-image micrometer, with a Nicol prism, the rotation of which equalises the brightness of the two contrasting limbs. Screens of red-

orange ($\lambda = 610$) and green ($\lambda = 540$) were used before the eyepiece in order to deal with the colour of the shadow. The 223 determinations made are grouped into 27 sets, and the results, compared with theoretical values, show good accordance. The author states that the colour remained white in the outer part of the shadow, but became redder and redder within it, and he calculates the coefficient of atmospheric transmission as 0.90 for the orange-red and 0.85 for the green. If the eclipse had been central he infers that the red light would have been equal to that of a star of magnitude -2.6 , an unusually bright eclipse. W. W. B.

492. Observations of Mars at Flagstaff. G. H. Hamilton. (Lowell Observat., Bull. No. 83. *Nature*, 108. p. 447, Dec. 1, 1921. Abstract.)—Nine drawings made on dates between March 8 and May 26, 1920, are reproduced. An unusually large number of white markings appeared near E. and W. limb, but disappeared in the centre; they are attributed to cloud or mist, and not to ground frost, as they partially obscured the "canals," even Syrtis Major. Similar drawings were made in 1903, so perhaps the phenomenon is a fixed seasonal one on Mars, only visible from the earth once in 15 years. The whitish areas have no dusky border, which tends to prove the reality of the dusky border seen round the polar cap. Some of the dusky regions seemed darker after being cloud-covered, suggesting growth of vegetation after rain. The inference is that weather on Mars instead of being quite insignificant is very marked, a conclusion reached many years ago by N. Lockyer. W. W. B.

493. Influence of Satellites on Form of Saturn's Ring. G. R. Goldsbrough. (Roy. Soc., *Phil. Trans.* 222. pp. 101–130, Oct. 13, 1921.)—Assuming that a planet is surrounded by concentric rings of particles describing nearly circular orbits of unperturbed, and neglecting, as a first approximation, the influence of one ring on another, we should expect, if particles are all equal, large perturbations in certain places, causing the particles of one ring to mingle with those of other rings, leaving a division. The particles may not be all equal, so it is next assumed that in any ring they are so numerous that all sizes, from smallest to largest, are represented there. In this case the author shows that the divisions would be extended, and therefore more readily visible. On the assumption that some of the particles are indefinitely small, he gets Cassini's division at once, and from its dimensions deduces the following results.

Mimas should produce a clearance of particles of from radius $20''.2$ up to itself, so the outer ring should end at $20''.2$. Its observed limit is $20''.01$. Mimas should also produce a division from radius $16''.9$ to $17''.64$. Cassini's division is observed from $16''.87$ to $17''.64$. Dione should produce a clearance from the surface of Saturn up to radius $9''.34$. The Crêpe ring is observed to begin with a diffused edge at $10''.83$. Rhea should produce a clearance of particles up to radius $13''.07$. The inner edge of ring B is observed at $13''.21$. The author also discusses the existence of the Crêpe ring in a dissipative area. He considers that the results might be still further improved by the inclusion of the effect of Saturn's oblateness, and the influence of one ring of particles on another. So far the theory agrees fairly closely with the salient features of the ring. The very fine divisions noted by Lowell and others are not explained by it, but the author gives reasons for not excluding their existence. He

concludes from the dimensions of the Cassini division that particles of all sizes up to a limit just short of that imposed by Maxwell for stability exist in the rings. In an appendix he gives the dimensions employed for Saturn and the rings, and the masses and mean distances of the satellites considered in his investigation. W. W. B.

494. Planetary Photography. E. C. Slipher. (Astron. Soc. Pacific Publ., June, 1921. *Nature*, 107. p. 725, Aug. 4, 1921. Abstract.)—Flagstaff photographs of Venus show no surface markings. Those of Mars number 100,000, many exposures being made on one plate in hope of catching moments of good definition. The author gives a long list of features he claims to have verified on the plates, but not all can be seen in the published reproductions. The very clear photographs of the polar cap suggest that this can be used for an independent determination of the position of the axis. In the Saturn photographs ring B is shown much brighter than ring A, which is semi-transparent, and allows the outline of the ball to be seen through it. The ring shows very faintly when the sun is near its plane. Two exposures were made on April 28, 1921, when earth and sun were on opposite sides of the plane of the ring, showing a dark stripe across the centre of the disc, narrowest in the centre, and curved in opposite directions at the edges. The five-fold belt in the southern hemisphere is shown very regular with edges exactly parallel to the equator. Photographs of Jupiter are also included.

W. W. B.

495. Variation in Size of Comet's Head. A. C. Gifford. (New Zealand J. of Sci., 4. pp. 248-253, Nov., 1921.)—Remarking that the diminution in size of comet's head at perihelion and its expansion on retreating from the sun has never been satisfactorily explained. The author considers it, taking Encke's comet as an illustration. He concludes after making various alternative assumptions as to the distribution of density that the primary cause of the diminution in size of the comet's head is the convergence towards perihelion of the orbits of the meteorites composing it. This diminution allows the mutual attraction of the particles to contract the swarm still further. This second gravitational diminution is a function of the distribution of density in the swarm, and is less as the materials condense more toward the centre of the swarm. He thinks that observations of changes in the diameter will afford a clue to this distribution of density. The differing periods of the different orbits will tend to spread out the swarm along the orbit, but this tendency is, he considers, overcome to some extent by the rapid oscillation of the particles in the case of most periodic comets. He asserts, moreover, that comets' heads are not completely vaporised, even at perihelion.

W. W. B.

496. Interior Limit of the Zone of the Asteroids. G. Armellini. (Accad. Lincei, Atti, 30. ii. pp. 201-203, Sept., 1921.)—It was till quite recently supposed that the inclination of the minor planets situated at the mean distance of 1.95, i.e. very near the "Leverrier point," was subject to violent oscillations (in the case of Hungaria more than 53 degrees). Since the asteroidal ring ends at this distance, its limit is now explained by the existence of the Leverrier point. In a previous note the author reduced Leverrier's 53 degrees to $3\frac{1}{2}$ [see Abs. 799 (1921)].

Hungaria and the minor planets situated at that distance are therefore no longer singular, the pretended explanation collapses, and the conclusion appears justified that the limits and lacunæ of the zone are due rather to cosmogonic causes than to mechanical perturbations. E. F.

497. *Physical Members of Pleiades Group.* R. Trumpler. (Lick Observat. Bull. 10. No. 333. pp. 110–119, 1921.)—Stars in the Pleiades region probably belong to the group if they are (1) apparently close to the centre of it, (2) of same proper motion, and (3) of similar spectral type. The author divides 246 stars into groups, containing: (A) Stars within 1° of Alcyone, down to 14.5 magnitude; (B) stars between 1° and 3° from Alcyone down to 9.0 visual magnitude. He has graded the stars according to the second criterion, distinguishing those whose centennial proper motion is within $1''$ of the mean of the group motion as *very probable* members; those between $1''$ and $1''.5$, *probable* members; and between $1''.5$ and $2''$ *uncertain* members. Those whose proper motion differs from that of the group by more than $2''$ he excludes, remarking that this limit is arbitrary. Most of the stars satisfy the third criterion also, only two being queried on this account. The author gives a diagram showing the relation between photographic magnitude and spectral type for the individual stars, and considers also the colour indices, luminosity law, and frequency of spectral types in the group. It contains eight double and one triple system, and also three stars suspected of being double. The parallax of the group derived from the luminosity of its members he finds to be $0''.008$. That derived from the orbital motion of the included double stars he finds to be $0''.010$.

He gives the following conclusions:—The Pleiades group is a cluster with a diameter of 10 parsecs, at a distance from the sun of 100 parsecs, and includes 300 to 500 stars. In an equal volume about the sun Eddington counts only 30 stars, so that the Pleiades group as a whole is 10 times more dense, and at its centre very much more crowded. The Pleiades are moving relatively to the sun in the direction of an apex at $82^\circ.5-40^\circ.0$ with velocity 27.5 km./sec. Alcyone is 600 times as bright as the sun. Most spectral types are represented, as in the stellar system, except that there are no red or yellow giants in the Pleiades. W. W. B.

498. *Spectrum of μ Centauri.* W. M. W[orrsell]. (Union Observat. S. Africa. Circ. No. 53. p. 108, July 25, 1921.)—The author quotes from Harvard Annals evidence that μ Centauri is a striking case of a star with bright H-lines subject to change. Photographs were taken with objective-prism on 6-in. photo-visual telescope at Johannesburg on panchromatic plates on 1915 May 9, 1919 July 10 and 15, 1920 May 18, and 1921 May 14. The first is the only one showing any indication of bright lines, and the indication is slight, being only a suspicion that the H_α dark line is superposed on a bright shading. W. W. B.

499. *Comparisons of Proper Motions in Zones $+66^\circ$ and -66° .* R. I[nnes]. (Union Observat. S. Africa, Circ. No. 53. pp. 106–107, July 25, 1921.)—The whole of the northern zone and two-thirds of the southern have been examined with the blink microscope. The longer exposures of the Melbourne repeat-plates (30 mins. against 12 mins. at Greenwich) is probably responsible for the larger number of stars shown in the southern zone. Stars showing displacement were plotted for each avail-

able hour of R.A. and compared, being generally enclosed in an elongated irregular oval. The centre of the oval is marked, and its position angle and distance from the centre of the diagram measured, with precautions to avoid the effect of personality. The assumed apex of solar motions was $18\text{h.} + 30^\circ$, but the observations show greater accordance between the zones for an apex at $17\text{h.} + 30^\circ$. Eliminating the solar motion with the revised apex, the stars appear spread out roughly parallel to the Milky Way. In the southern hemisphere there is a preference of direction along increasing R.A. of the Milky Way, but there is no such preference in the northern.

W. W. B.

500. *Stellar Magnitudes in Star Clusters. XIII. Variables in N.G.C. 7006.* H. Shapley and B. W. Mayberry. (Nat. Acad. Sci., Proc. 7. pp. 152–154, May, 1921.)—[For other clusters see Abs. 56 and 620 (1921).] Accordant results by four different methods give for this cluster a parallax of $0''.000015$, making it the most distant measured cluster.

Examination of 9 plates, 6 taken with the 60-in. reflector and 3 with the 100-in., shows 11 variables, 7 showing conspicuous variation in a single night and the other 4 also appearing to be of short period. They are thus taken to be typical short-period Cepheids, such as are commonly found in globular clusters. The median magnitude of the 7 and also of the 11 stars is found to be 18.96 , which, adopting -0.23 (determined at Mt. Wilson) as the median photographic absolute magnitude of the short-period Cepheids means a distance of 69,000 parsecs, and confirms the parallax figures. The diameter of the cluster probably exceeds 300 light-years. No effect of selective scattering of light in space is shown, although the distance appears to be 225,000 light-years.

W. W. B.

501. *Spectrum of η Centauri.* W. M. W[orrsell]. (Union Observat. S. Africa, Circ. No. 53. p. 108, July 25, 1921.)—This star is said to have a variable spectrum. It was photographed with 6-in. objective prism in 1921 May 28. H_α bright, fairly intense, accompanied on red side by H_α dark line. H_β dark, sharp, narrow, half the intensity of H_γ , faint bright edging on violet side and perhaps on red side, faint dark companion on violet side. H_δ rather out of focus appears to have companion on red side. The line 4025 is distinctly double, the fainter towards violet. K seems to be a faint broad dark band, almost disappearing with magnification. Three probably He-lines, 5876, 5016, and 4922 between H_α and H_β . Variability seems to be certain.

W. W. B.

502. *Parallax of ζ_2 Reticuli.* W. M. W[orrsell]. (Union Observat. S. Africa, Circ. No. 53. p. 107, July 25, 1921.)—The star has a large proper motion, but its parallax does not appear to have been measured. From photographs taken with the 6-in. objective of the Franklin-Adams twin telescope the author obtains a preliminary result for the parallax $+0''.10 \pm 0''.08$. It should therefore be determined with a more suitable instrument.

The P.M. is $1''.47$ in direction 63° , and a similar P.M. is found for ζ_1 Reticuli, about $6'$ distant.

W. W. B.

503. *Changes in the Crab Nebula in Taurus.* J. C. Duncan. (Nat. Acad. Sci., Proc. 7. pp. 179–180, June, 1921.)—Lampland having recently

detected changes in the Crab Nebula (M.1) from a comparison of seventeen photographs with the 40-in. Lowell reflector during 8 years, the author has examined two plates taken with the 60-in. Mt. Wilson reflector, one on 1909 Oct. 13 and the other on 1921 April 7. The first was made by Ritchey on a Seed 27 plate, giving 3 hours' exposure with aperture stopped down to 54 in. The second being nearer the sun had a shorter exposure of 80 minutes, but as a faster plate, Seed 30, was used with the full aperture, the densities of the plates are nearly equal. They were placed in the stereocomparator, and it was obvious that changes in the relative luminosity of different parts of the nebula had occurred, especially in the bright region N.W. of centre, and that certain filaments and condensations had moved generally away from the centre.

By measurement of coordinates of twelve nebulous condensations and thirteen comparison stars, the movements in right ascension and declination of the condensations in the $11\frac{1}{2}$ years have been determined. A plate of the nebula is given with motions marked on it showing the displacement of the twelve points if the motion be assumed constant for 500 years: all seem to be moving outwards, but this does not prove that the nebula as a whole shares the motion. There is very little evidence of rotation.

W. W. B.

504. Angular Diameter of Arcturus by Interferometer. F. G. Pease. (Nat. Acad. Sci., Proc. 7. pp. 177-179, Jan., 1921.)—In continuation of previous work [see Abs. 91 (1922)] further results are given. Aldebaran shows fringes of gradually decreasing visibility at 13, 14.5, and 19 feet, but it is not yet certain whether they vanish between the last two distances, or beyond the reach of the present apparatus. A longer beam will certainly be required for Pollux, and probably for α Ceti.

Arcturus at 16 ft. separation showed a reduction to 20-25 % of the zero fringes, at 17.5 ft. 15-20 %, at 18.25 ft. 15 %, at 19 ft. 5 %, and at 19.5 ft. no fringes were visible. When a longer beam is available the accuracy of this result can be further tested, but provisionally it gives an angular diameter of $0''.0237$, in very good agreement with the estimated value of Eddington, Russell, and Hertzsprung. Adopting a mean value for the parallax, this gives a diameter about 22 times that of the sun.

Future observations will be much facilitated by two screws driven by a single motor now being mounted on the beam, to keep the moving mirrors equidistant from the fixed ones, instead of the previous slow hand movement.

W. W. B.

505. Orbit of Σ 1834. W. H. van den Bos. (K. Akad. Amsterdam, Proc. 24. 1, 2 and 3. pp. 72-77, 1921.)—From a survey of all the observations available up to 1921, the author derives elements including a period of 295.6 years. The object has been very difficult, as the plane of the orbit is nearly in the line of sight, so that twice during a revolution the components are too close for measurement. At these times the comparison of observed with computed angles shows large residuals. During the next ten years observations will be much easier, and corrections may be made to some of the elements.

W. W. B.

506. Ultra-Violet Spectrum of α Cygni. W. H. Wright. (Lick Observat., Bull. 10. No. 332. pp. 100-108, 1921.)—The spectrum resembles that of novæ, but ordinary comparisons have generally stopped short at the

violet. Hartmann and Kohl have gone as far as 3680 Å., and the present paper extends the examination to 3250 Å., beyond which the silver mirror fails to reflect. A further limit 3000 Å. imposed by atmospheric absorption may be reached if the mirror can be eliminated. The observations now given were obtained with the 2-prism quartz spectrograph of the Crossley reflector. One photograph was made on a glass plate focused for the limited region 3250 Å. to 3550 Å., and the other two on films bent to the curvature of the field, one having a narrower slit. Where in good focus the glass plate has the best definition, and the film with narrower slit is superior to the other except for intensity. So each photograph contributes something special, the films naturally including a greater range than the plate.

The Balmer H series is measurable as far as H_{∞} , after which it becomes too faint. A rhythmic set of lines is shown at 3706·2, 3715·5, 3727·6, 3741·7, and 3757·9, which may be continued by the H-lines 3697 and 3687, but it is not suggested that this is a real series, as it is incomplete and all the lines have been identified.

Details are given of the method of measurement and the tables used for standardisation (Rowland and Exner and Haschek). The intensities are compared with Mitchell's estimations of the intensity of corresponding lines in the chromosphere. Practically all the metallic lines appear to be enhanced, except those due to Fe. Cr and Mn are exceptionally strong in the star.

W. W. B.

507. Formation of Double Stars, Etc. E. Belot. (Comptes Rendus, 173. pp. 703-706, Oct. 24, 1921.)--The assumption made is that large nebulae, dispersed in space, must in some cases be penetrated by stars travelling in line. Impact with the nebula would slow down the motion of the penetrating star, and especially that of the first one, so that the second might very possibly come near enough for mutual attraction to set up orbital motion. An extension of this to more stars would cover the case of multiple stars as well as binaries. A further extension relying on the resultant curvature of path on penetrating the nebula suggests independent swarms being compelled to converge and not only form globular clusters, but by carrying off a portion of the nebula as they emerge, produce small nebulous masses which, concentrating naturally about some convenient stellar nucleus, become planetary nebulae.

W. W. B.

508. The Local Star-System. A. Pannekoek. (K. Akad. Amsterdam, Proc. 24. 1, 2 and 3. pp. 56-63, 1921.) The author shows that by the method of Kapteyn and Van Rhijn, which points to a stellar distribution in more or less concentric bun-shaped surfaces, if the numbers of stars per magnitude from magnitude 4 to 16 is known the space density may be computed in the Milky Way for distances from 100 to 2500 parsecs, and in the polar regions from 80 to 1000 parsecs.

Inasmuch, however, as the observations are far from complete, he considers the data available in the Bonn Durchmusterung, Schönfeld's southern continuation and the Cape Durchmusterung, and also in the Stratonoff regions. The last named which go down to faint magnitudes, are of very limited extent, and the zone catalogues do not go fully beyond the 9th magnitude. It is evident that there is a considerable uncertainty in the inferred numbers for the fainter magnitudes. Kapteyn's "selected

areas" give some further assistance, and the author derives figures with a diagram of the extension of the star system in different longitudes with suggestions to account for some of the more marked variations, but admits the provisional character of the whole, and mentions various considerations such as absorbing nebulae which may modify all the results for space-density.

W. W. B.

509. *Star Colours. Vatican Observations.* (Nature, 108, p. 164, Sept. 29, 1921.)—Four volumes just published by the Vatican Observatory deal with observations of star colours on Schmidt's numerical scale, modified by Osthoff. Vol. I contains the observations of Benedetto Sestini at Rome (1844-6) revised by J. G. Hagen. Vol. II those of F. Krüger at Aarhus. Vol. III those of H. Osthoff at Cologne. Vol. IV is an index catalogue, combining the results of the other three, and giving Harvard magnitudes and spectral types. On the whole, colour varies regularly with type, but Osthoff discusses a physiological effect by which a bright star is estimated as relatively whiter than a faint star of the same type. His experiments on the point gave an average difference of 0.3 colour unit per magnitude. For this reason photographic determinations are to be preferred to visual ones.

W. W. B.

510. *Lines in Visual Spectrum of α Cygni.* W. W. C[ampbell]. (Lick Observat., Bull. 10. No. 332. p. 108, 1921.)—Miss Waterman in a paper published in 1913 [see Abs. 420 (1914)] recorded that a single-prism spectrogram of α Cygni showed no lines between H_α and the B group (6872), but grating spectrograms showed a large number of strong lines there, which she thought at first might belong to the blue region of the third-order spectrum, but after tests gave up the idea. In 1920 she reverted to the third-order suggestion, and the Director had a series of triple-prism spectrograms made by Shane on special plates. These prove that the lines do actually belong to the third-order spectrum. Of Miss Waterman's other statements Shane confirms the large displacement of the H_α absorption line towards the violet, amounting to $1.4 \text{ \AA.}$, and also the bright line bordering the H_α absorption on the red side. Shane found also a faint line attributed to the D_3 line of He.

W. W. B.

511. *Diameter of α Orionis with Interferometer.* A. A. Michelson and F. G. Pease. (Nat. Acad. Sci., Proc. 7. pp. 143-146, May, 1921.)—In pursuance of the plan foreshadowed in a previous paper [see Abs. 51 (1921)], the 20-ft. beam was mounted on the end of the Cassegrain cage of the 100-in. reflector. Details of the moving parts are given, and a full explanation of the principle on which the measurements depend. The instrument was tested on Vega in Aug. 1920, and on β Persei and γ Orionis in Dec. 1920, which did not show the extinction of fringes found with α Orionis. A separation of mirrors of 13 ft. was tried on α Ceti, Aldebaran, and Pollux, with promising results. It was then felt that the measurement of α Orionis could be considered valid, and it was accordingly reduced. Assuming that the effective wave-length of the star is $5.75 \times 10^{-5} \text{ cm.}$ the angular diameter comes out at $0''.047$, which if the mean value $0''.018$ be taken for its parallax, means an actual diameter of 240 million miles, or slightly less than that of the orbit of Mars.

In this determination a uniformly illuminated disc has been assumed. Darkening towards the limb equal to that of the sun would increase the

diameter by about 17 %. Correction may also be required to the assumed wave-length of the star and to the instrumental measurements (distance between mirrors, etc.).

W. W. B.

512. *Double-Star Orbits from Incomplete Data. II. G. C. Comstock.* (Astron. J. 33. pp. 163-168, Aug. 2, 1921.) [For previous paper see Abs. 1240 (1921).]—Generally the observed position angles give a much better determination of the orbit than the observed distances. The author points out that when the inclination of the orbit plane is very great the value of the distance observations is relatively much enhanced, and proposes a special method of utilising them. By means of subsidiary curves control of the elements of the true orbit is obtained without necessarily constructing the apparent orbit. The latter, however, should also be traced, as it must be an ellipse, thus affording a further control. The star chosen for illustration of the method is γ Coronæ Borealis = Σ 1967. Observations extending back from the author's 1918 observations to those of Struve between 1826 and 1832 are grouped, and elements of the true orbit are deduced, giving a period of 101 years, which is longer than previous determinations. It appears that Struve's observations differ systematically from others at the same part of the orbit.

W. W. B.

513. *Dependence of Orbital Eccentricity upon Relative Masses of Components. C. D. Perrine.* (Astron. J. 33. pp. 180-184, Sept. 9, 1921.)—The author claims the validity of a general law, applicable not only to spectroscopic binaries, but also to visual binaries, and to the planets and satellites of the solar system. For instance, of the four inner planets, Mercury, the smallest, has the greatest eccentricity, and Mars, the second smallest, the second greatest eccentricity, while the orbits of the Earth and Venus, which are much larger, are nearly circular. The four great planets do not fit in well with this, but they also have small eccentricities, while the small outer satellites of Jupiter and Saturn have much more eccentric orbits than the inner ones.

Comets being of very small mass have orbits approaching maximum eccentricity. A list is given of spectroscopic binaries classified to show the dependence of eccentricity upon mass ratio, and also of 57 visual binary systems; but with these it is necessary to assume a direct relation between mass and brightness. The author tries to draw conclusions as to a possible cause, such as a resisting medium, and discusses the bearing of different evolution hypotheses with regard to this and to the high radial velocities of the spiral nebulae; but no definite law emerges, though he thinks it probable that pure capture is often responsible for large eccentricities.

W. W. B.

514. *Spectrophotometry of Carbon Stars. P. Salet.* (Comptes Rendus, 173. p. 828, Nov. 7, 1921.)—These stars with banded spectra, Secchi's Type IV, are so faint, especially in blue rays, that very little has been done in regard to their spectrophotometry. The author, using Nordmann's colour-screen method, has compared eight of them with stars of solar type of equal intensity in the red, and tabulated the differences of intensity in the green and blue. All of them are about one magnitude fainter in the green and on the average two magnitudes fainter in the blue. The great faintness in the blue may be due either to low temperature or general absorption, but the author inclines to the belief that it

is due to the increasing absorption bands as the type progresses from white to red stars.

W. W. B.

515. Determination of Effective Temperature and Colour Index of Certain Stars. C. Nordmann and Le Morvan. (Comptes Rendus, 173. pp. 72-75, July 11, 1921.)—The author has employed a heterochrome photometer to determine the brightness of certain stars through a red screen or blue one, tabulating the results for these in the form: $\log (R/B)$. From these he deduces the effective temperature. The colour index is $-2.5 \log (R/B)$, and these are compared with King's values. The stars are arranged in order of magnitude of the results, and show the expected order of spectral class very nearly, the temperatures ranging from $27,700^\circ$ for ζ Persei down to 3050° for η Geminorum. He considers the probable error to amount to 8 % for a deduced effective temperature of 5000° . There is a very good agreement between his determinations of colour-index, and those of King, Parkhurst, Schwarzschild, and others. With the Mt. Wilson 100-in. reflector, he considers, his method can be applied down to 12th magnitude stars. Rosenberg's photographic method only gives a range between $400 \mu\mu$ to $500 \mu\mu$, whereas the author's extends from $460 \mu\mu$ to $600 \mu\mu$.

[Errata: *ibid.*, p. 400, Aug. 16, 1921.]

W. W. B.

516. Heterochrome Photometry. C. Nordmann. (Comptes Rendus, 173. pp. 380-382, Aug. 16, 1921.)—In reference to a previous paper [see preceding Abs] which he wrote in collaboration with Le Morvan, the author points out that the method may be tested by anybody with any other form of photometer, with the necessary and sufficient condition that to obtain rigorously comparable results in the measurement of the distribution of intensity in stellar spectra, exactly the same colour-screens must be used, whatever the procedure followed in other details. He gives the formula for the red, green, and blue screens he used, consisting of liquids in glass vessels with parallel faces.

W. W. B.

517. Spectroscopic Determination of Parallaxes. D. L. Edwards. (Observatory, 44. pp. 234-242, Aug. 1921.)—Taking as his text the catalogue of 1646 stars whose parallaxes have been measured by the spectroscopic method at Mt. Wilson, the author explains the method adopted, and the basis on which it was founded. The spectra of bright stars photographed for radial-velocity work provided material of two classes, one of comparatively near stars, whose parallax had been measured, and the other of generally very distant stars. These latter being on the whole brighter, showed clearly that their absolute magnitudes must be very much greater than those of the former. The spectra of the two groups showed three classes of difference. The intrinsically brighter stars showed more general absorption in the ultra-violet, but this was of small value in tabulation, owing to the general faintness of the continuous spectrum. They also showed H-lines abnormally strong, but the rapid variation of these with spectral type rendered this also of small value in deducing absolute magnitude. There remained the fact that the intensities of certain metallic lines were stronger in these stars, and of others weaker than in the other class. This is really the basis of the spectroscopic determination of parallax. The author points out how closely the inferences drawn from these variations of intensity agree with Lockyer's

previous conclusions in regard to enhanced lines as a criterion of temperature.

He gives a detailed account of the procedure at Mt. Wilson and also at the Norman Lockyer Observatory, where a similar investigation is in progress, with a short list of the pairs of metallic lines used as standards, and mentions some sources of error that must be kept in view. He then discusses the relative importance of the sources from which standard absolute magnitudes may be obtained for fixing the reduction curves, namely trigonometrical parallaxes, parallactic motions, and proper motions.

The second method, by parallactic motions, is applicable to large groups of very distant stars, especially Cepheid variables, and from his work on these Adams found an indication that dwarf stars as a whole have a velocity different to that of stars in general.

The 1646 stars in the catalogue under discussion include a very few fainter than 9th magnitude, and most of the stars belong to the lower spectral types (F to M), owing to the comparative paucity of lines in higher type spectra; but the value of the method is undoubted, and its application is bound to become wider and to embrace more and more of the problems of stellar distribution and evolution. W. W. B.

518. *Intrinsic Brightness and "Effective Diameters" of Stars.* **C. Nordmann.** (Comptes Rendus, 173. pp. 578-581, Oct. 10, 1921.)—Wil-sing has just published in the Potsdam Annals work on the colour, brightness, and diameters of stars, derived from Planck's law of radiation. The author claims that he employed this very method ten years ago, and he now compares his results with those of Wilsing, adjusting them for the different adopted parallaxes, and for the notable difference in their adopted value of the sun's brightness. The stars common to the two are Sirius, Procyon, Aldebaran, Vega, γ Cygni, α Persei, Polaris, β Andromedæ, and Algol. The agreement is, he thinks, quite good, taking into consideration the difficulty of the observations. The largest of the stars appear to be Aldebaran and β Andromedæ, whose diameters in terms of that of the sun were given by the author in 1910 as 13.5 and 13.0 respectively, Wilsing's values in 1920 being 15.8 and 24.0. The name "effective diameter" he also claims as his own, and proceeds to argue that his heterochrome photometer can reach for this purpose stars of 7.5 magnitude with an aperture of 0.27 m., while the Potsdam 0.80 m. spectrophotometer can only reach stars of 4.5 magnitude. This means that for equal apertures the heterochrome photometer will reach stars 5.36 magnitudes fainter; or 1000 times as many, compared with the spectrophotometer [see Abs. 320 (1911)]. W. W. B.

519. *Comparison between Visual and Photographic Observations of Nebulæ.* **G. Abetti.** (Accad. Lincei. Atti. 30. ii. pp. 47-50, July, 1921.)—The systematic use of photography for the study of nebulæ enables us to institute an interesting comparison with the visual observations made before its application to astronomical research. In the years 1876-1879 observations and drawings of nebulæ were made by G. Tempel with the Amici equatorial at the Arcetri Observatory, but have not been published, although the Accademia dei Lincei offered to defray the cost of publication, Tempel not being satisfied with the methods of reproduction then employed. Among the photographs of nebulæ made in

recent years by Pease with the Mount Wilson 60-in. reflector are some nebulae which were drawn by Tempel, and the author has compared these photographs with Tempel's original drawings. These show remarkable perfection and accuracy, considering that they were executed with an equatorial of 28 cm. aperture and 5.29 m. focal length, whereas the photographs were made with a reflector of 152 cm. aperture and 7.60 m. focal length, and with long exposures. Variations in the form of the nebulae in the limited period that has elapsed between the drawings and the photographs are improbable and difficult to verify, yet a certain change in the relative positions of stars and nuclei may be detected, and Tempel worked to scale with such precision that the accuracy of his observations can hardly be doubted. Similar comparisons extended to all the nebulae drawn and observed by him would be useful, and the publication of his drawings is desirable.

E. F.

520. *Aurora, Magnetic Disturbance, and Sun-Spots.* **A. L. Cortie.** (*Nature*, 108. p. 272, Oct. 27, 1921.)—In connection with an observation of Aurora Borealis on Sept. 28–29, the author writes that on the same day a magnetic disturbance was recorded at Stonyhurst. He considers it to be another return of the great disturbance of May 12 to 21, which, he says, occurred in accordance with the solar rotation period, on June 6–10, July 7–9, Aug. 3–5, Sept. 2, and Sept. 28–29, the last two being more intense than any of the others since May. He mentions another sequence of disturbances from May 21 to Oct. 5, with the June member missing. In most of these there was no active disturbance visible on the sun, and the author emphasises the caution that this does not weaken the connection between solar activity and terrestrial magnetic disturbance, though admitting a difficulty in accounting for an increase of disturbance under such apparently quiescent solar conditions.

W. W. B.

LIGHT.

521. Transmission Colours of Sulphur Suspensions. C. V. Raman and B. Ray. (Roy. Soc., Proc. 100. pp. 102-109, Oct. 4, 1921.)—The experiments carried out by Keen and Porter [Abs. 645 (1914)] are repeated with a view to clearing up the doubt, suggested by Rayleigh, whether the well-known effect is really due to transmitted light in the technical sense of the term. It is found that the suspension does indeed, after a certain stage in the growth of the particles, begin again to transmit light regularly, in the strictest optical sense of the term, since the coloured light passing through is capable of forming sharply-defined optical images. A discrepancy between the figures for the dimensions of the particles as given by Keen and Porter, and those obtained in the present work, is noted. The theory of the colours is developed mathematically from fundamental considerations and a quantitative explanation of the phenomena is advanced. A. B. C. L.

522. Effect of Temperature upon Transmission of Infra-Red Radiation through Glasses. G. Rosengarten. (Phys. Rev. 16. pp. 173-178, Sept., 1920.)—*Measurements of Infra-Red Transmission.*—The use of coloured glasses as absorption screens for transmitting bands of monochromatic radiation depends upon the variation in the transmission of the radiation with change in temperature. The region investigated extends from 1μ to 5μ . The temperature was varied from 40° to 460° C. The radiation from a tungsten lamp was passed through glasses placed in an electric heater. The transmission of radiation of various wave-lengths was observed by means of a spectrometer using a pair of large rocksalt prisms which could be rotated through any desired angle and the radiation of varying wave-length made to fall on the slit of a thermopile. The intensity of radiation was determined by the deflection of a highly sensitive galvanometer.

Conclusions; Transmission Independent of Temperature.—The results appear to indicate that to within ± 8 per cent. the variation in temperature produces no change in the transmission of infra-red radiation through the coloured glasses tested. AUTHOR.

523. Double Refraction in Quickly-cooled Glass. Taffin. (Comptes Rendus, 173. pp. 1347-1350, Dec. 19, 1921.)—A special apparatus was designed for measuring the double refraction of specimens of glass first heated and then cooled quickly in air. The apparatus consisted essentially of a plate of glass 5 to 6 mm. thick, 5 cm. long and 2 cm. wide. This was mounted in a sort of press, and the force acting on the glass could be varied at will. If e is the thickness of glass traversed by the light, a the length in the perpendicular direction, the force per unit surface is F/ae , and the double refraction Δ produced is proportional to this. If K is the coefficient of proportionality, the difference of path corresponding to the thickness of glass e will be $\delta = \Delta e = KF/a$. In using the apparatus for measuring the double refraction of a specimen

of glass, the glass plate of the compensator is placed between crossed nicols whose principal sections are inclined at 45° to the horizontal. The specimen under test is next oriented to obtain maximum path difference. The compensator is then loaded, and the displacement observed of the two black lines which separate two zones where the tensions in the specimen are of opposite sign. These lines, initially near the lateral faces and parallel to these faces, approach one another and become curved; then they join, and the bright centre of the prism of glass is surrounded by a black circle. If the pressure is further increased, this circle contracts more and more, and for a certain pressure the bright central point disappears. The corresponding difference of path δ is noted. If E is the path length for the light in the prism studied, its double-refraction X is given in absolute measure by $X = \delta/E$. A. W.

524. Magnetic Double-Refraction of Gold Colloids. Y. Björnsthål. (Phil. Mag. 42. pp. 352-368, Sept., 1921.)—Monochromatic light was polarised by a Thomson-Glan prism and passed through a tube containing the colloid placed between the poles of a Svedberg electromagnet giving a field of about 20,000 gauss. The Zsigmondy method of preparing the colloids was chosen, and the size of the particles was determined partly by the rate of settling and partly by the ultramicroscope. The variation of double refraction with the field is such that the phase retardation increases with the intensity and is positive. The effect is about four times as great as that caused by nitrobenzene under similar conditions. With a series of dilutions, after the first, the effect is proportional to the concentration. When light of different colours is used, the double refraction increases with the wave-length, being greatest for red light. This behaviour is opposite to that of ordinary liquids. The effect also changes with the size of the particles; it becomes noticeable with a "degree of dispersity" of $12\mu\mu$, passes through a maximum and a minimum, and again increases with great rapidity. It is deduced that the form of the particles is not spherical; they are assumed to be ellipsoids of revolution, and reasons are given for concluding that the ellipsoid tends to turn its major axis parallel to the direction of the applied field. In the colloidal gold solutions the metal is an allotropic modification of ordinary gold. [See also Abs. 983 (1920).] G. E. A.

525. Magnetic Double-Refraction of Liquid Mixtures. S. Procopiu. (Comptes Rendus, 173. pp. 353-355, Aug. 8, 1921.)—Previous work concerned the electric double-refraction of mixtures consisting of crystalline particles in suspension in a liquid of the same index of refraction [Abs. 1414 (1921)]. Similar experiments have now been carried out with magnetic fields of from 2000 to 5000 gauss. From the results obtained with a number of different substances it is concluded that the double refraction in a magnetic (or electric) field, of a liquid mixture formed by a crystalline powder in a liquid of the same refractive index, will be positive if the optic and magnetic (or electric) signs of the crystal are of the same sense, and negative if the signs are opposed. This admits of simple explanation.

Depolarisation of Light by Liquid Mixtures. (Ibid., pp. 409-411, Aug. 22, 1921.)—Certain experiments tend to show that mixtures of liquids and crystalline powders have a depolarising action. This

depolarising action, which is practically zero for pure liquids, and extremely small for mixtures containing non-crystalline powders or crystalline particles of the cubic system, is particularly noticeable with liquid mixtures exhibiting double refraction. The depolarisation is found to be proportional to the concentration of the crystalline particles in the mixture.

A. W.

526. Convection Coefficient in a Dispersive Medium. A. Anderson. (Phil. Mag. 42. pp. 509-511, Oct., 1921.)—In considering the velocity of light of given period in a transparent medium, such as the water in Fizeau's experiment, in motion away from the source, an expression for the difference of water path measured is found which differs from that given by Cunningham ["The Principle of Relativity," p. 63], and the features of the difference are briefly discussed. A table is given showing the connection coefficients for four particular wave-lengths according to (a) Fresnel's formula, (b) Cunningham's formula, (c) a formula developed in the present paper, and (d) the values found in Zeeman's experiment. It is admitted that for only one of the four wave-lengths does formula (c) give a closer approximation to the experimental results (d) than formula (b).

A. B. C. L.

527. Annealing of Glass. E. D. Williamson. (Washington Acad. Sci., J. 12. pp. 1-6, Jan. 4, 1922.)—Describes a mathematical treatment of the equations representing the results of experimental work previously described by the author and L. H. Adams [see Abs. 1587 (1920)]. Formulæ are found which, used in conjunction with tables of the elastic and annealing constants of a glass, show at what temperature to hold the glass, how long to hold it at that temperature, and how rapidly to cool it in order to get any degree of fineness of annealing in the least possible time. By the use of the method it is found that a 15 % reduction of time can be made in the annealing process. The paper concludes with a worked out example, and a further paper will give detailed schedules for various types of glass on the new basis.

J. W. T. W.

528. Radiation-Pressure. R. N. Ghosh and N. K. Sur. (Phys. Rev. 18. pp. 380-384, Nov., 1921.)—*Derivation of the Formula for Radiation-Pressure.* Larmor's formula was derived on the assumption that the energy density of the radiation is proportional to $1/\lambda^2$. The same formula is now derived for a pulse with an energy distribution in accordance with Wien's law. If the reflector is moving toward the source with a speed v and if we assume that the amplitude for each component part of the incident pulse is unchanged by reflection, then because of the change of wave-length on reflection (Doppler effect) there is a change in energy density per sec. which is equal to the corresponding radiation-pressure times v . Hence $p\lambda = 2\epsilon\lambda(c+v)/(c-v)$ and the total pressure is $2I(c+v)/c(c-v)$, when I is the intensity of the total radiation.

AUTHORS.

529. Reflecting Echelon Grating. A. Lo Surdo. (Accad. Lincei, Atti, 30. i. pp. 136-139, March 6, 1921.)—Describes the theory of an echelon grating in which the light is reflected instead of transmitted. The formulæ obtained for the resolving power, the angle between suc-

cessive spectra, etc., are analogous to those found in the case of a transmission grating. The advantages of the reflection form are (*a*) much greater dispersive power, (*b*) the resolving power is approximately three times that of a transmission grating of similar dimensions, (*c*) the wavelength interval between successive spectra is approximately one-third. The second part of the paper describes experiments made with Hilger transmission gratings used as reflection gratings. Two sizes were employed and the superior resolution obtained by reflection was very marked. The author considers that it is now possible to obtain optical perfection sufficient for the practical production of such a grating, and moreover, it is not open to the objection of loss of light when a large number of laminae are employed.

J. W. T. W.

530. Talbot's Bands and the Theory of the Lummer-Gehrcke Interferometer. N. K. Sethi. (Phys. Rev. 18. pp. 389-395, Nov., 1921.)—*New Simple Method of Observing Talbot's Bands.*—If a thin strip of cover glass is immersed in a dispersive medium, such as a suitable mixture of CS₂ and benzene, with a refractive index such that the group velocity in it is less than in the plate, and if a vertical slit illuminated with white light is observed through the glass strip held in a vertical plane very oblique to the plane of the incident light, two out of the four spectra formed by the edges of the plate exhibit Talbot's bands. The theory of the formation of the bands in this way is closely similar to that of the Lummer-Gehrcke plate, and as in the latter, the maxima are narrow and the minima crossed by secondary maxima when the number of internal reflections is small. The appearance, too, is not affected by opening the slit wide.

Interference bands analogous to those given by a Fabry-Perot etalon were also observed with the same simple arrangement. The appearance and behaviour of these bands are described and explained. AUTHOR.

531. Scattering of Light by Gases. M. Born and W. Gerlach. (Zeits. f. Physik, 5. 5 and 6. pp. 374-375, 1921.)—The Bohr-Debye model of the hydrogen molecule has been generalised and extended to oxygen and nitrogen by Sommerfeld [Abs. 520 (1918)], who tested his assumptions by means of the observed and calculated dispersions in these gases. It is here pointed out that the scattering of light, arising from molecular anisotropy, affords a good test of the accuracy of the molecular model. The experimental results of Strutt and Gans [Abs. 1677 (1921)] are discussed in relation to the theoretical values calculated from Born's formulæ [Abs. 572, 573 (1919)]. It appears that, while there is agreement between observed and calculated values as regards order of magnitude, there is no approach to numerical agreement, and hence the molecular model cannot be accurate. A. W.

532. Diffraction of Light Incident at nearly the Critical Angle on the Boundary between two Media. B. N. Chakravarty. (Roy. Soc., Proc. 99. pp. 503-511, Sept. 1, 1921.)—An ordinary prismatic spectroscope is adjusted to give large dispersion by putting the prism in such a position that the light incident on the first face, after passing through it, falls at nearly the critical angle on the second face, and emerges nearly grazing the surface. To study the diffraction pattern obtained

with this arrangement, the aperture of the prism is limited by a slit or slits between the prism and collimator. Photographs of the diffraction pattern are reproduced, and these exhibit a decidedly asymmetrical character. An explanation of this asymmetry is given.† Some of the results obtained have a bearing on the theory of the Lummer-Gehrcke plate [Abs. 1362 (1903)].

A. W.

533. Absorption Bands in the Ultra-Violet and Magnetic Birefracton. **G. Massol and A. Faucon.** (Soc. Chim., Bull. [iv]. 25 and 26. pp. 585–588, Nov., 1919).—The authors find that the liquids and solutions which show absorption bands are the same as those in which Cotton and Mouton observed magnetic birefracton; in some cases electric birefracton (Kerr-effect) goes together with absorption. In most cases these properties are characteristic of some double-bond; this holds for all aromatic compounds (cyclohexane has no double bond and no birefracton); aliphatic bodies have no double bonds either, but side-chains may favour absorption; ketones and aldehydes behave exceptionally.

H. B.

534. Photographic Efficiency of Heterogeneous Light. **F. C. Toy.** (Roy. Soc., Proc. 100. pp. 109–118, Oct. 4, 1921).—Some sources of illumination are much more active photographically than others, and one of the most active of all artificial sources is the mercury-vapour lamp. The energy of the radiation from this lamp is concentrated in a comparatively few spectral lines, and most of these are in that region of the spectrum which is the region of greatest absorption by the silver halide grains of which the photographic emulsion is composed. This, in itself, may be the complete explanation of the intense photographic activity of this particular illuminant, but the question arises as to whether the explanation is, in part, merely the fact that the light is concentrated into a few wave-lengths, apart altogether from any consideration of the absorption coefficient. In other words, a given quantity of radiant energy absorbed in the grains may give a greater photographic effect when it is all of one frequency than when it is a complex radiation such as white light. The object of the present paper is to discuss this question in the light of recent researches on the photographic plate. This idea has recently been brought forward by Slade and Higson [see Abs. 422 (1921)] with special reference to the quantum theory. They have suggested that when the photographic plate is illuminated by heterogeneous light, the radiations of different frequencies act independently, i.e. they do not reinforce one another in producing the photochemical effect, and that white light may be considered as consisting of an enormous number of such independent monochromatic radiations. That is to say, the probability of a grain being changed depends not only on the total energy absorbed but also on the number of different kinds of energy of which that total is composed. If this theory is correct, the extent to which it affects the efficiency (i.e. the ratio of the photographic effect to the intensity of the light producing it) of any given light will depend on the form of the law connecting the effect (A) with the intensity of the light (I). This question is considered and values of A found experimentally are compared with the values as calculated from the empirical equation obtained

from $A = aI(1 - e^{-\beta I})$ by putting $a = 2.25$ and $\beta = 2.5$, and in every case excellent agreement is found. As a result of the present work it is concluded that over the spectral range used in these experiments radiations of different frequencies do not act independently in producing the photochemical change, but probably simply as a total amount irrespective of any difference in quality. It is difficult to imagine how the theory which is discussed could be valid unless it is supposed that the molecules contain an enormous number of oscillators each vibrating simple harmonically with a slightly different period and each responding only to a particular frequency in the incident light. This would imply that the atom contained as many different kinds of oscillators as there are homogeneous trains into which the spectrum can be resolved. There is no evidence to support such a view of atomic structure. A. E. G.

535. Absorption Spectrum of Oxygen. J. Duclaux and P. Jeantet. (Comptes Rendus, 173. pp. 581-583, Oct. 10, 1921.)—A study was made of the ultra-violet absorption spectrum of oxygen, using a spectrograph with a water prism. The results here given deal with the region from $\lambda 1900$ to $\lambda 2000$. *First group.*—Part of this spectrum is already known. It consists of a number of bands which can be resolved into lines, and comprised between $\lambda 1830$ and $\lambda 1960$. Bloch has given seven of these bands. An eighth band has been found. The frequencies of its components can be expressed by the Deslandres' formula $N = 50,727 - 2.8 m^2$, where $m = 1$ to 9. This band prolongs the series of seven, and is situated just where extrapolation would place it. It is followed by a ninth band whose head is at about $\lambda 1997$, but precise measurements of this have not yet been made. *Second group.*—In the same region a new system of bands has been discovered, similar to the first system. Four of these bands have been found between $\lambda 1900$ and $\lambda 2000$. The Deslandres' formulæ for these are:—

- II. $N = 52,616 - 3.1 m^2$ ($m = 1$ to 10),
- III. $N = 52,116 - 3.1 m^2$ ($m = 1$ to 10),
- IV. $N = 51,585 - 3.0 m^2$ ($m = 1$ to 10),
- V. $N = 51,021 - 3.0 m^2$ ($m = 1$ to 8).

The bands are much weaker than those of the first group, and only appear if the thickness of oxygen traversed exceeds 50 cm.

Comparing the bands III, IV, and V of the first and second groups, it is seen that the structure of the bands of the two groups is exactly the same, and the first frequency-difference for the heads of the bands is also the same for the two groups. Hence the second group follows from the first by a simple translation of the frequency scale. All the lines of the second are obtained from the corresponding lines of the first group by subtracting 1555 from the frequency. The new group is not limited to the four bands now given. Two others on the red side and two or more on the violet side have been found, but measurements in these regions are more difficult. A. W.

536. Optical Measurement of Electron Affinity. J. Franck. (Zeits. f. Physik, 5. 5 and 6. pp. 428-432, 1921.)—A discussion of the work of Kossel, Born, and others leads to the conclusion that the limits of the continuous spectra observed with certain elements may be used to

determine electron affinity. Steubing has observed, in the emission spectrum of iodine vapour, a continuous spectrum which fades away to zero at about $\lambda = 4800 \pm 15 \text{ \AA.U.}$ The vanishing of the spectrum is not attributable to lack of photographic sensitivity on the part of the plates employed, and does not appear to be related to the ionisation potential in any way. Reasons are advanced for connecting the disappearance at $\lambda 4800$ with the electron affinity, and calculation gives then the value 2.57 volts, or 59.2 cal. For bromine and chlorine the values are similar, since they give similar continuous spectra. The limit of the continuous spectrum given by bromine was found by Eder and Valenta to be about $\lambda 4200$. This would give an electron affinity of 2.93 volts, or 67.5 cal. The conclusions to be drawn from these values with respect to Born's theory of crystal structure, will be given in a later paper by Born and Gerlach. A. W.

537. *On the Exploded Wire Spectrum of Calcium.* **R. A. Sawyer** and **A. L. Becker.** (Phys. Rev. 18. p. 164, Aug., 1921. Paper read before the Am. Phys. Soc.)—The spectra of exploded wires of calcium and several other elements have been photographed. By expending constant power upon wires of varying mass, or varying power upon wires of constant mass, a series of explosions of varying temperature has been obtained. It has been possible to obtain spectra in which the relative intensities of the three Ca lines, H, K, and $\lambda 4227$ vary as they vary in the spectra of the different classes of stars. These three Ca lines also appear more prominently in the spectra of exploded wires of other metals than the spectra of the metals themselves. The amount of calcium present must be very minute. It is therefore probable that the calcium lines, particularly H and K, are tremendously enhanced by the very high temperature of the explosion. The intense Ca lines of the solar flash spectra have seemingly required considerable quantities of the heavier Ca to be above the hydrogen layers of the solar atmosphere. The present results explain this anomaly as primarily a temperature effect. AUTHORS.

538. *Line Spectra of Cadmium and Zinc in the Electrodeless Ring Discharge.* **A. Hagenbach** and **H. Schumacher.** (Zeits. wiss. Phot. 19. pp. 129-141, Nov., 1919.) A further study of the observation made by Hagenbach and Frey [Abs. 192 (1918)] that the electrodeless ring discharge gave more Cd and Zn lines than the condenser spark. Measurements are taken from the low red (with dicyanin sensitiser) down to ultra-violet, $\lambda 6500$ to 2100 , the latter with quartz prisms. A solenoid of 2 or 3 turns in circuit with 3 Leyden jars surrounds the quartz tube, 7 cm. or 5 cm. in diameter; a P_2O_5 tube is found to suppress mercury lines (Gaede pump). The electrodeless discharge is very powerful. The spectrum differs from the arc and spark spectra, and contains new lines. H. B.

539. *Spectra of Lead Isotopes.* **T. R. Merton.** (Roy. Soc., Proc. 100. pp. 84-88, Oct. 4, 1921.)—In a previous paper [Abs. 374 (1920)] an account was given of comparative measurements of the wave-length of the line $\lambda = 4058 \text{ \AA.}$ in the spectra of ordinary lead and of the leads obtained from uranium and thorium minerals respectively. It is a matter

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of some interest to discover whether the observed wave-length differences are to be found between all the corresponding lines in the spectra of the isotopes; whether the spectrum lines are shifted as a whole, or whether different lines are affected to a different extent or in a different direction. In the present investigation a comparison has been made between the spectra of a sample of lead from Australian carnotite and of a sample of ordinary assay lead prepared by Messrs. Johnson, Matthey. The results of the investigation are summarised in the following table:—

λ .	λ (Carnotite Lead) — λ (Ordinary Lead).	Wave-number (Ordinary Lead) — Wave-number (Carnotite Lead).
4058	$0.0110 \pm 0.0008 \text{ \AA.}$	0.065 ± 0.005
3740	0.0074 ± 0.0011	0.053 ± 0.008
3684	0.0048 ± 0.0007	0.035 ± 0.005
3640	0.0070 ± 0.0003	0.052 ± 0.002
3573	0.0048 ± 0.0005	0.037 ± 0.004

The significance of these results is discussed in conclusion. A. B. W.

540. Band Spectra of Isotopes. **L. Grebe** and **H. Konen.** (Phys. Zeits. 22. pp. 546–549; Disc., 549, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag., Jena, Sept., 1921.)—Measurements of selected parts of the band spectra of uranium lead and ordinary lead gave a mean wave-length difference of about $0.055 \text{ \AA.U.}$ for the higher members of a selected series, the order of magnitude of this result being in agreement with the assumption of diatomic molecules as carriers for the band spectrum. [See Abs. 413 (1913) and 374 (1920).] A. W.

541. Band Spectrum of Zinc in the Electrodeless Ring Discharge. **A. Hagenbach** and **H. Schumacher.** (Zeits. wiss. Phot. 19. pp. 142–148, Nov., 1919.)—The measurements, by means of iron arcs, extend from $\lambda 4895$ down to $\lambda 3469$ and reveal several bands not shown in the previous spectra of Emily Howson, 1912; Morse, 1904; and Hartley and Ramage, 1902. H. B.

542. Arrangement of the Cyanogen Bands. **A. Kratzer.** (Phys. Zeits. 22. pp. 552–555, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag., Jena, Sept., 1921.)—Continuing previous work [Abs. 861 (1921)] the present paper discusses the series arrangement of the cyanogen bands. Formulæ, based on the quantum theory, are obtained for the frequencies. One of these provides a theoretical basis for the band series laws of Deslandres. The calculated wave-lengths and frequencies are presented in a series of tables, the results obtained showing good agreement with experimental data given by Heurlinger [Abs. 1071 (1920)] and others. A. W.

543. Spectroscopic Analysis of the Hydrogen Spark; Stark-Lo Surdo Effect. **G. Polvani.** (N. Cimento, 22. pp. 323–342, Nov.–Dec., 1921.)—Describes work on the composition of the light emitted from a spark
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in a hydrogen atmosphere, similar to that done in the case of air [Abs. 1566 (1921)]. The electrodes were of aluminium. The changes of intensity of the various lines are described, as well as the effect of the introduction into the hydrogen of a very small quantity of air. Both oscillating discharge and continuous brush discharge were investigated.

A second part of the paper deals with the broadening of the lines due to the Stark-Lo Surdo effect, while the concluding section discusses the origin of the luminosity of the hydrogen spark. J. W. T. W.

544. Variable Fine Structure of the Balmer Series. **E. Gehrcke** and **E. Lau.** (Phys. Zeits. 22. pp. 556-557, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag., Jena, Sept., 1921.)—It has been shown previously [Abs. 1988 (1921)] that the intensity ratio of the components of one of the doublets of the Balmer series depends on two factors. Variation of the pressure in the discharge tube varies the intensity ratio. The variation is greatest for H_{α} and progressively smaller for the higher members of the series. The results show that the variation of the intensity ratio is approximately proportional to the square of the term number.

The width of the discharge tube used has also an appreciable effect. With a tube 5 cm. long and about 1.5 mm. wide the long-wave component is the stronger, while at the same time both components are weakened. A discussion of the results with reference to Sommerfeld's theory shows that the observed doublet separation is from 20 % to 25 % smaller than that calculated from theory, and this discrepancy cannot be ascribed to experimental errors. A. W.

545. Radiation and Ionisation produced by Electron Bombardment in Pure and in Impure Helium. **F. Horton** and [**Miss**] **A. C. Davies.** (Phil. Mag. 42. pp. 746-773, Nov., 1921.)—An outline is first given of the development of ideas concerning the arrangement of the two electrons in the helium atom, starting from the authors' determination of the minimum radiation voltage and the minimum ionisation voltage for normal helium. In this connection the theoretical deductions of Bohr, Landé, Franck and Reiche, and Kemble are discussed, and the experimental work of K. T. Compton [Abs. 867 (1920) and 501 (1921)] and of Franck and Knipping [Abs. 251 and 1279 (1920)] is considered and criticised. In view of the fact that these experimenters claim that their results prove the occurrence of certain effects, which, in both cases, are not in agreement with the results of the authors' previous work with low pressures of helium, and which, moreover, are not reconcilable with each other, the main points wherein the deductions of these workers extend beyond the authors' former conclusions have been directly investigated, using a specially designed apparatus, over a wider range of pressures than that used before. *Pure helium.*—The experiments show that in pure helium: (1) Radiation is produced by the impacts of electrons with 20.4 volts energy, in confirmation of the earlier conclusion of the authors, but in disagreement with the most recent conclusion of Franck and Knipping. (2) A second type of radiation is produced at 21.2 volts, in agreement with the conclusions of Franck and Knipping. (3) The 21.2-volt radiation ionises abnormal helium produced by 20.4-volt electron impacts, and with a relatively higher gas pressure the detected effects of ionisation may swamp those

of radiation. This result provides an explanation of the ionisation of helium by electrons having less than the normal ionising velocity which is essentially different from that offered by Compton. (4) Both types of radiation can be absorbed and subsequently re-emitted by normal helium atoms, so that they are passed from atom to atom throughout a volume of the gas. (5) For velocities below the normal ionising velocity, the amount of ionisation produced as the result of electron impacts on abnormal helium atoms, under the experimental conditions used, is small in comparison with that resulting from the ionising action of the 21.2-volt radiation. *Impure Helium*.—The possibility of the presence of a small quantity of impurity in the helium facilitating the production of radiation at 20.4 volts was investigated, but no evidence that the impurity acts in this way was obtained.

It is concluded that the significance of the experimental results in connection with theories of the arrangement of the two electrons in the normal helium atom lies in the fact that they indicate that the limitations of the selection principle are not applicable to the fundamental displacements of the outer electron of the helium atom. [See also Abs. 296 (1921).] A. W.

546. Hydrogen Spectra from Long Vacuum Tubes. R. W. Wood. (Phil. Mag. 42. pp. 729-745, Nov., 1921.)—A continuation of work previously described [Abs. 1600 (1920)]. In a tube of great length, containing hydrogen with a suitable trace of water-vapour, the centre of the tube exhibits the Balmer series, with the secondary spectrum reduced to $1/50$ of its usual intensity. The ends of the tube (to a distance of about 40 cm. from the electrode bulbs) show the secondary spectrum strongly developed in addition to the Balmer series. The phenomena are of the same nature with a direct current of high potential as with the alternating current from a transformer; i.e. the secondary spectrum develops at both the anode and cathode. No explanation has yet been found for these peculiarities. With the tube in this condition, the central portion shows a bright "flash" of the secondary spectrum on closing the switch, the duration of the flash being of the order of $1/50$ sec. On opening the switch the gas recovers its initial condition in about $1/5$ sec., and shows the "flash" again on closing the switch.

Secondary Spectrum and Balmer Series.—The secondary spectrum is attributed to molecular hydrogen by recent investigators (Merton, Stark, and others). The first rush of current appears to break down the molecular hydrogen with the emission of the "flash," leaving only atomic hydrogen in the centre of the tube (which gives the Balmer lines). On stopping the current, molecular hydrogen appears to be re-formed in about $1/5$ sec. This break-down, however, appears to require the presence of a trace of water-vapour. With a very weak current, the secondary spectrum is fairly strong at the centre of the tube, while the Balmer lines are weak or absent. Increase of current strength weakens the secondary spectrum, which passes through a minimum of intensity as the current grows stronger; the Balmer lines increase steadily in intensity as the current is augmented. These effects can perhaps be explained as due to the fact that molecular hydrogen is re-formed as rapidly as it is broken down into atomic hydrogen, in the case of a feeble exciting current. As the current

strength increases the proportion of atomic hydrogen becomes greater, the secondary spectrum weakens, and the Balmer lines become stronger. This, however, does not go on indefinitely; apparently the percentage of molecular hydrogen cannot be reduced below a certain minimum value. With dry hydrogen and a tube thoroughly freed from water-vapour, the Balmer lines disappear entirely from the whole tube (with the exception of a very faint trace of H_{α}). In this stage a strong group of lines appears in the ultra-violet between the 4th and 5th Balmer lines. The origin of these lines has not yet been determined. With the tube in this, the "white" stage, operation with condenser discharges gives a red discharge which shows the Balmer lines strongly developed. This indicates that momentary currents of several thousand amperes are able to break down the molecular hydrogen even in the absence of water-vapour.

Argon and Helium.—Experiments with these gases are not yet completed, and will be described in a later paper. A. W.

547. Excitation of Enhanced Spectra in Low-Voltage Arcs. P. D. Foote, W. F. Meggers, and F. L. Mohler. (Phys. Rev. 18. pp. 128–129, Aug., 1921. Phil. Mag. 42. pp. 1002–1015, Dec., 1921.)—Sommerfeld has shown that enhanced spectra probably arise from the removal of more than one electron from the normal atom. Discussion of this shows that in the case of the alkaline earths the enhanced spectra should be doublets, characteristic of the "arc" spectra of the alkali metals, but with $4N$ instead of N appearing in the simple spectral series formulæ. Also the separation of the doublets in the enhanced spectrum of an alkaline earth should be approximately four times that for the corresponding alkali. These conditions are confirmed by existing data. The highest convergence frequency in the arc spectrum (nuclear charge e) of an alkali earth is $1.5S$, corresponding by the quantum relation $h\nu = eV$ to the amount of work required to remove one valence electron. Similarly the frequency for the simple enhanced spectrum is 1.5σ , corresponding to the amount of work required to remove the second valence electron after the first has been removed. Some of these latter frequencies have been summarised by Fues [Abs. 83 (1921)]. For magnesium, on the basis of Sommerfeld's theory, the enhanced spectrum should be excited in a low-voltage arc by a 15-volt impact. Experimental work carried out by the authors has verified this. While at 8 volts only the ordinary "arc" spectrum appears, practically every enhanced line listed by Fues is excited in a 20-volt arc. The reason these lines do not appear prominently in an ordinary arc is that electrons of 20 volts velocity are infrequently produced, even though the applied potential exceed this. The mean free path is so small that the velocity loss of 7.61 volts, resulting in ionisation and the "arc" spectrum, maintains the velocity of most of the electrons at approximately this value or less. In the present work a 3-electrode tube was used, with the grid very close to a hot tungsten filament and the anode at a considerable distance and in metallic contact with the grid, the whole being immersed in the vapour at a low pressure. Hence it was possible to develop any desired velocity in so small a distance that collision with atoms was infrequent, and the electrons could then pass into the force-free space between the grid and anode where collision and emission of radiation took place.

This method of producing enhanced spectra opens a new field whereby the truly enhanced lines may be determined immediately upon examination of the photographic plates, since the enhanced spectrum is not produced below the second ionisation point. In ordinary arcs, on the other hand, some electrons are accelerated, without collision, for several mean free paths, far enough to accumulate velocity sufficient for the production of the second type of ionisation, with radiation characteristic of the spark. This is probably one reason why so little is known of the enhanced spectrum of mercury. Photographs have been obtained by the new method for mercury, but the values of the higher critical voltages have not yet been determined. A. W.

548. Grid Structure in Echelon Spectrum Lines. N. A. Kent and L. B. Taylor. (Am. Acad., Proc. 57. pp. 3-18, Dec., 1921.)—Nutting has observed a peculiar fluting or grid structure which appeared in many echelon spectrum lines [Abs. 1053 (1906)]. Kent also observed similar effects [Abs. 1836 (1912)]. Nutting concluded that the structure was real and indicated an actual discontinuity of emission in the source. Experiments recently carried out all give evidence against any discontinuity of emission in the source. A. W.

549. Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry. S. J. Lewis. (Soc. Arts, J. 69. pp. 785-791, Oct. 14; 799-809, Oct. 21, and pp. 821-828, Oct. 28, 1921. Cantor Lectures.)

550. Polarisation and Intensity in the Complex Zeeman-Effect. P. Das. (Calcutta Math Soc., Bull. 12. pp. 151-158, Dec., 1921.)—In a previous paper [Abs. 124 (1922)] it was shown that the complex Zeeman-effect obeying Runge's law may be accounted for by an atomic model based on Sommerfeld's theory. The present paper gives a discussion, based on Bohr's correspondence principle, of the polarisation and intensity-distribution of the components, as well as the limit to the number of these components.

The grid is simply due to a secondary action of the echelon when the line under investigation is not sufficiently monochromatic. The results obtained emphasise the fact that when an echelon is used to measure small wave-length differences, great care must be taken to obtain the lines so narrow that their width is less than $1/5$ of the distance separating the two orders when the echelon is arranged in the double-order position, or else secondary action may enter to cut off an edge of a line and thus give a false intensity-maximum position. A. W.

551. Anomalous Zeeman-Effect and Series Systems of Neon and Mercury. A. Landé. (Phys. Zeits. 22. pp. 417-422, Aug. 1, 1921.)—The first part of this paper collects together earlier results of quantum-theory analysis of Zeeman terms, presenting these results in the form of rules concerning combination, polarisation, and intensity. The complete series systems of neon and mercury are next arranged by means of a rule for selection combined with the rules given above. The agreement with experiment, as regards the number, position and

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intensity of the Zeeman components, establishes the connection between the types of magnetic separation and the line multiplicities with no magnetic field, which was previously obtained theoretically from the quantum theory. [See Abs. 132 (1922).] A. W.

552. Intensity Asymmetry in the Stark-Effect for the Balmer Lines. A. Rubinowicz. (Zeits. f. Physik, 5. 5 and 6. pp. 331-334, 1921.)—Stark and Lunelund [Abs. 437 (1915)] have shown that there is in general a difference in intensity in the fine structure components which the Stark-effect gives rise to in the Balmer lines. The present paper shows that by making use of Bohr's correspondence principle it is possible to explain this asymmetry of intensity. [See Abs. 1437 (1915).] A. W.

553. Effect of an Electric Field on Absorption Lines. R. Ladenburg. (Phys. Zeits. 22. pp. 549-552, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag., Jena, Sept., 1921.)—The research here briefly described is concerned with the question whether the absorption lines of non-luminous alkali vapours, in particular the D-lines of sodium, are appreciably influenced by an electric field. By means of a Lummer interference plate, and using fields of the order of 100,000 volts/m. it was found that there was a definite displacement of both absorption lines (Na D-lines) towards the red. Observations with polarised light showed that the p -component was appreciably more displaced than the s -component. The effect was found to be independent of the direction of the field. The displacement appeared to increase more rapidly than the first power of the field strength, and within the errors of experiment (about 20 %) was approximately proportional to the square of the field strength. The displacement of the red edge of the D_2 line for a field of 160,000 volts/cm. was about 0.02 Å.U. Research on the higher series members and on those of lithium, for which a greater effect is to be expected, has been commenced. A. W.

554. New Effect of Radiation. VI. F. Welgert. (Zeits. f. Physik, 5. 5 and 6. pp. 410-427, 1921.)—Earlier researches were concerned with the effects of linearly polarised light on layers of photochloride in gelatine or collodion [Abs. 106 and 570 (1920), 79 and 650 (1921)]. The work now described deals with the effects of linearly polarised light on layers of collodion coloured with cyanin. It was found that the presence of oxygen is of importance as regards the phenomena of absorption in such layers. With these layers, again, the property of dichroism, both qualitatively and quantitatively, behaves differently from the bleaching of the colouring material. When complete bleaching is obtained, the dichroism passes through a maximum. The absolute value of the dichroism is always very much less than the extinction variation. In this respect the effects differ from those observed with photochloride layers, for which the variations of extinction and dichroism agree both qualitatively and quantitatively. Freshly prepared cyanin-stained collodion layers are the most sensitive; the sensitiveness decreases with the duration of the excitation, so that the quantity of light absorbed is smaller. No simple relation was found between the quantity of light absorbed and the density of the colouring material, but increased

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sensitivity was observed with decreased colour density. The latter part of the paper discusses the mechanism of radiation transformation.
A. W.

555. Action of Infra-Red Rays on Phosphorescence. M. Curie. (Comptes Rendus, 173. pp. 554-555, Oct. 3, 1921).—By means of the arrangement previously described [Abs. 1079 (1921)] for following the action of infra-red rays on the phosphorescence of numerous substances, it is found that extinction phenomena are shown by all sulphides and by these alone, although to different degrees. This observation is in accord with Ives and Luckiesh's theory of the phenomenon [Abs. 161 (1912)], which is based on a supposed agitation of the atoms of sulphur under the action of infra-red radiation; such agitation should produce increase in the frequency of the collisions with the electrons detached from the active elements at the time of the excitation of the phosphorescence and should hence result in diminution of the luminosity. An attempt has been made to verify this hypothesis by examining the reflection of a bundle of X-rays from the face 110 of a crystal of cubic blende, when under and also when not under the influence of infra-red radiation. Although the work of Bragg and Bragg has shown that this face 110 contains atoms of sulphur and zinc, no variation in the reflected radiation could be detected. Negative results were likewise obtained when the faces 001 and 111 of a sulphur crystal were examined. T. H. P.

556. New Radiation of Short Wave-length. G. Reboul. (Comptes Rendus, 173. pp. 1162-1165, Dec. 5, 1921).—In a previous paper [Abs. 520 and 1149 (1921)] the author has shown how it is possible for a badly conducting substance carrying a current, to affect a photographic plate. This effect was considered to be due to the emission of a very soft type of X-radiation from the feebly conducting substance. The present investigation proves that this hypothesis is correct and a determination has been made of the absorption coefficient, and consequently the approximate wave-length, of the radiation. The radiation is totally absorbed in a layer of air 2 mm. to 3 mm. in thickness at atmospheric pressure. The absorption coefficient has been measured more accurately at reduced pressures by a method due to Holweck [Comptes Rendus, 171. p. 849 (1920), and 172. p. 439 (1921)] and found to be 16, with a p.d. of 450 volts applied to the badly-conducting material. This result requires the radiation to be placed in a region of the spectrum between the shortest ultra-violet and the longest known X-rays. A. B. W.

557. Absorption of X-Rays. W. E. Williams and B. L. Worsnop. (Nature, 108. pp. 306-307, Nov. 3, 1921).—The authors, who are at present engaged on an investigation of the relation between X-ray absorption coefficients and critical frequencies, refer to a recent publication by Richtmeyer [Abs. 1779 (1921)] who gives the absorption curves of Mo and Ag for homogeneous X-rays on both sides of their respective critical (K) absorption frequencies, and for Pb on the longer-wave side. Data by Hull and Rice [Abs. 1249 (1916)] supply the information for lead on the shorter-wave side. Plotting $\log (\tau/\rho)$ against $\log \lambda$ the double values of the mass absorption coefficient (fluorescent) of Mo and Ag can be determined at their respective critical frequencies. The following results are obtained for the ratio of the values

$[(\tau/\rho)\nu_k + \delta\nu]/[(\tau/\rho)\nu_k - \delta\nu] = R$, where ν_k is the K critical absorption frequency of an element and $\delta\nu$ is infinitely small.

Element.	Lead.	Silver.	Molybdenum.
R	3.5	6.76	7.06
Crit. Frequency ν_k	21.58×10^{18} sec.-1	6.186×10^{18} sec.-1	4.854×10^{18} sec.-1

The relation between R and the critical frequency is linear and is expressed by $R = 0.212 \times 10^{-18}(38.1 \times 10^{18} - \nu_k)$. The relation between R and the atomic number has also been tested, but it does not appear to be nearly as linear as the one given above. A. B. W.

558. Velocity of X-Ray Electrons. R. Whiddington. (Cambridge Phil. Soc., Proc. 20. pp. 442-444, Nov., 1921.)—A preliminary account is given of experiments on the magnetic spectrum of the secondary radiation excited at the water-cooled target of an X-ray tube. With the apparatus described it was possible to obtain a spectrum photograph in about 30 minutes. The magnetic and photographic arrangements employed are similar to those used by Rutherford for the determination of the velocity of β -rays and later used by Rawlinson and Robinson in an experiment on X-ray electrons.

Using a Pt or Rh target and a copper foil over the slit, the strongest lines on the film correspond to velocities 6.02×10^7 and 5.74×10^9 cm./sec. Applying the quantum relation to the X-ray K doublet of copper the corresponding velocities of electrons carrying the same energy are found to be 5.61×10^9 and 5.33×10^9 cm./sec.

It is of interest to note that while the differences are precisely the same in both experimental and calculated cases, the actual values differ by about 10 %. Further investigation is necessary to decide whether this difference is real or is due to some peculiarity in the experimental arrangement. A. B. W.

559. Theory of Absorption of X-Rays by Matter, and the Principle of Correspondence. L. de Broglie. (Comptes Rendus, 173. pp. 1456-1458, Dec. 27, 1921).—In an earlier paper [Abs. 462 (1921)], the author has obtained an expression for the coefficient of atomic absorption of a substance for a radiation of wave-length λ , namely:

$$\mu_{at.} = \frac{\alpha}{8\pi k c} \cdot \lambda^3 \sum_p n_p E_p^2, \quad k \text{ being Boltzmann's constant, } c \text{ the velocity of light, } E_p \text{ the critical energy of the } p\text{th electronic layer, } n_p \text{ the number of electrons in this layer. The sum } \sum \text{ extends to all the absorption discontinuities of wave-length greater than } \lambda.$$

The present paper deals with the evaluation of the constant α from known X-ray data. A. B. W.

560. Low-Voltage X-Radiation from Arcs in Metallic Vapours. F. L. Mohler and P. D. Foote. (Phys. Rev. 18. pp. 94-95, Aug., 1921.)—The authors outline an investigation of the critical potentials above

the resonance potentials and first ionisation potentials. Potassium gives a sharp break in the radiation curve at $23 \pm$ volts, and another break at 20 ± 1 volts at increased vapour pressure. Sodium gives a break in the curve at 35 ± 1 volts, and magnesium at 46 ± 1 volts. The X-ray wave-length La_1 for Mg can be computed by Duane's law. It gives La_1 at $\lambda = 263 \text{ \AA.}$ or 46.9 volts, the observed value being 46 volts. Similarly the Na and K potentials are found to be in good agreement with observation.

A. B. W.

561. Polarisation of Secondary X-Rays. **A. H. Compton** and **C. F. Hagenow.** (Phys. Rev. 18. pp. 97-98, Aug., 1921.)—Making experiments similar to those of Barkla on the polarisation of X-rays, the authors conclude that approximately 70 % of the total secondary radiation at 90 % is of the fluorescent type, this result indicating that the fluorescent, as well as the scattered, rays are completely polarised. Barkla's experiments show that the general radiation from an X-ray tube is only partly polarised, which makes it difficult to support the view that the general fluorescent radiation is excited in exactly the same manner as the primary X-rays.

A. B. W.

562. Width of X-Ray Spectral Lines. **L. Gilchrist.** (Phys. Rev. 18. pp. 89-94, Aug., 1921.)—Since certain instrumental factors which affect the width of spectral lines of ordinary light are not effective in the case of X-ray spectral lines, it appears to be justifiable to investigate the conditions that might exist in the source of the X-rays, i.e. in the target of the X-ray tube, which would account for the width of a line in the spectrum. The author investigates mathematically the question of Doppler-effect in the velocities of the atoms in the target and calculates such velocities in the cases of certain spectral lines observed by Duane. Measuring the width of these lines and the angular distance between the successive orders, calculations indicate that the atomic velocities in the target are of the order 12 to 14 m. per sec.

A. B. W.

563. High-Frequency Limits of X-Ray Spectra at Different Angles from the Kathode Stream. **D. L. Webster.** (Phys. Rev. 18. p. 155, Aug., 1921.)—Preliminary results only are quoted. For tungsten up to a voltage of 67 kilovolts *no difference between the high-frequency limits has been found* at different angles from the kathode stream. The accuracy of measurements is about 1 % and the angles used are 55° and 145° .

A. B. W.

564. X-Ray Absorption Frequencies of the Chemical Elements. **W. Duane.** (Nat. Acad. Sci., Proc. 7. pp. 260-267 and 267-273, Sept., 1921.)—The author calculates the critical K and L absorption frequencies of the elements, the calculation being based on the Rutherford-Bohr theory of atomic structure. It is shown that the agreement between theory and observation is very close, the computed values being equal to the observed values within one or two per cent.

A. B. W.

565. X-Ray Bulb with Liquid Mercury Antikathode. **A. Müller.** (Phil. Mag. 42. pp. 419-427, Sept., 1921.)—A description is given of a novel

type of X-ray tube in which liquid mercury functions as the antikathode. With this tube spectrograms of the L-series of mercury have been obtained, using the revolving crystal method, rock salt being employed as the reflector. The final results are given in the following table—using Siegbahn's notation for the series lines. The lines have been identified by comparing them with the corresponding lines of gold (79), thallium (81), and lead (82). Mercury has the atomic number 80.

Line.	$\lambda \times 10^{11}$ cm.	ν/N .
<i>l</i>	1418.3	642.5
<i>a</i> ₂	1249.7	729.2
<i>a</i> ₁	1238.5 $\pm$ 0.3	735.69
η	1161.9	784.3
β ₆	1077.4	845.8
β ₄	1068.6	852.7
β ₁	1045.8 $\pm$ 0.6	871.35
β ₂	1037.5 $\pm$ 0.4	878.33
β ₃	1030.1	884.6
β _{7/5}	1007.8	904.2
γ ₅	914.4	996.6
γ ₁	893.5 $\pm$ 0.7	1019.9
γ _{2/3}	869.5	1084.0
γ ₄	834.8	1091.6

The third column of the table contains the frequency of the Hg lines divided by the Rydberg frequency N. A. B. W.

566. *Mass-Spectra of the Alkali Metals.* **F. W. Aston.** (Phil. Mag. 42. pp. 436-441, Sept., 1921.)—An apparatus is described for the production of positive rays of the alkali metals by means of a hot anode, considerable experimental difficulty being encountered. With this apparatus the following results have been obtained:—

Element.	Atomic Number.	Atomic Weight.	Minimum Number of Isotopes.	Mass of Isotopes in Order of Intensity.
Li	3	6.94	2	7, 6
Na	11	23.00	1	23
K	19	39.10	2	39, 41
Rb	37	85.45	2	85, 87
Cs	55	132.81	1	133

The table indicates that Na and Cs appear to be simple elements, whilst Li, K, and Rb are in each case mixtures of two isotopes.

The relations between these figures and those previously obtained with the halogens and the inactive gases are briefly discussed. A. B. W.

567. *Scattering of X-Rays by Anisotropic Liquids.* **E. Hückel.** (Phys. Zeits. 22. pp. 561-563; Disc., 563, Oct. 1 and 15, 1921. Paper VOL. XXV.—A.—1922.

read at the Deut. Physikertag., Jena, Sept., 1921.)—The author has succeeded in demonstrating, by the well-known X-ray transmission method, a crystalline structure in the following substances in various conditions from solid to liquid:—

1. *Liquid (flüssige) Crystals.*

- (a) Para-azoxyanisol—solid, turbid, and clear liquid.
- (b) Para-azoxyphenetol—solid, turbid, and clear liquid.
- (c) Di-anisaldazin—turbid.

2. *Plastic (fliessende) Crystals.*

- Cholesterylpropionate—solid, turbid, clear liquid.
- Cholesterylbenzoate—turbid.

These substances were contained in a thin-walled (0.01 mm.) vessel of Al which itself showed crystalline formation. Reproductions of the original photographs are shown in illustration of the points raised in the paper. These photographs are strong evidence of the persistence of the crystalline form of the solid crystal in the molten state. A. B. W.

568. Degradation of the Quantum in the Successive Transformations of High-Frequency Radiations. L. de Broglie. (Comptes Rendus, 173. pp. 1160–1162, Dec. 5, 1921.)—The progress of knowledge of the photo-electric effect appears to prove that the absorption as well as the emission of a radiation of frequency ν , is in a manner discontinuous by equal quanta $h\nu$. The electrons expelled from the atom by the absorption of a quantum are emitted with a kinetic energy equal to the quantum absorbed, less the work required in escaping from the atom. The atom, which is thus deprived of an interior electron, possesses an energy greater than the normal energy of other atoms of the same type. According to present ideas on the subject, it tends then to return to its normal condition by emitting, under the form of a series of lines, the supplementary energy which it has, so to speak, given up from its store. Each radiation being emitted with its own quantum, it appears as if the quantum absorbed by the substance under the radiation is again re-emitted in a lower form as several quanta of lower frequency.

These phenomena present curious analogies with those of thermodynamics. Just as heat tends to pass from hot to cold bodies so radiant energy tends to pass from high frequencies to lower frequencies. The quantity, Energy of radiation/Frequency, is analogous to entropy; it has the dimensions of "action" and varies by multiples of h .

A. B. W.

569. Reflection of X-Rays by Crystals. H. A. Wilson. (Phys. Rev. 18. pp. 396–401, Nov., 1921.)—The derivation of the expression for the total reflected energy as obtained by other physicists, is given in simpler form. It is shown that the reflected rays are parallel in the plane of incidence but diverge in the perpendicular plane. Making the simplifying assumption that no ray is reflected more than once from any plane of atoms and that the absorption by the crystal is negligible, expressions for the intensity at any point in the reflected beam are derived. It is shown that interference fringes are to be expected whose distance apart under ordinary circumstances may be of the order of

4×10^{-4} cm. The error due to the above-mentioned simplifying assumptions can be corrected by multiplying by the appropriate exponential factor. AUTHOR.

570. X-Ray Spectra. D. Coster. (Zeits. f. Physik, 6. 3. pp. 185-203, 1921.)—A detailed study of the fine structure of the X-ray spectra of the elements tantalum to uranium.

A concise abstract is not possible.

A. B. W.

571. X-Ray Spectra. G. Wentzel. (Zeits. f. Physik, 6. 2. pp. 84-99, 1921. Extract of Dissertation, Munich.)—A general discussion of the theory of X-ray spectra, dealing mainly with "niveau" and line schemes, and doublet-relationships on the basis of the principle of probability.

No short abstract is possible.

A. B. W.

572. Precision Measurements in X-Ray Spectra. M. Siegbahn. (Comptes Rendus, 173. pp. 1350-1352, Dec. 19, 1921.)—The author refers to improvements in X-ray spectrometry developed by him since 1918. The following example serves to illustrate the degree of accuracy it is now possible to obtain with the most recent apparatus and methods.

ANGLE OF REFLECTION OF THE FIRST ORDER OF THE K_{α} -RADIATION OF COPPER FROM CALCITE.

Polished Face of Crystal.	Rough Cleavage Face.
14° 42' 2".8	14° 42' 0".0
14° 41' 59".8	14° 41' 59".9
14° 41' 59".6	14° 41' 59".2
14° 42' 1".3	14° 41' 58".0
14° 41' 59".5	14° 41' 59".6
14° 42' 2".3	14° 42' 5".5
Mean 14° 42' 0".8	Mean 14° 42' 0".4

As will be seen, the difference observed between the two crystals is inappreciable and a mean value of 14° 42' 0".6 may safely be taken as correct, with an approximation greater than one second, i.e. to 0.002 per cent. Taking the reticular distance of calcite to be $\log 2d = 0.7823347$ at 18° C., the value of the wave-length of the K_{α} line of copper is given by $\lambda = 1537.302 \times 10^{-11}$ cm. The author found in 1918 with a less accurate spectrograph, the value $\lambda = 1537.36$.

A. B. W.

573. Critical Potentials relative to the K and L Discontinuities in the Absorption Spectrum of Aluminium. New Determination of Planck's Constant. Holweck. (Comptes Rendus, 173. pp. 709-712, Oct. 24, 1921.)—If a determination is made of the transparency T of a substance for X-rays produced by a kathode stream of velocity corresponding to the potential drop V (T being the measure of the intensity of the rays traversing the substance, taking the incident radiation equal to

100), the curve $T = f(V)$ shows a point of discontinuity when V has the value $V = h\nu/e$, where h is Planck's constant, e the elementary charges, and ν the frequency of the absorption discontinuity of the substance under consideration. This singular point will become more sharply marked if the incident rays are filtered.

The author describes an investigation in which the critical values of ν are determined by crystal reflection methods, and consequently the critical values of h . Using aluminium absorbers the values of λ in the K and L series were found to be :

$$\text{K series, } \lambda = 7.95 \pm 0.05 \times 10^{-8} \text{ cm.}$$

$$\text{L series, } \lambda = 193.5 \pm 4 \times 10^{-8} \text{ cm.}$$

Or, using the value $K\lambda$ for aluminium measured by H. Fricke [Abs. 1604 (1920)], namely, $\lambda = 7.9470 \times 10^{-8}$ cm., the critical potential K being 1555 ± 10 volts (obtained by the author), the value of Planck's constant is found to be $h = 6.55 \pm 0.02 \times 10^{-27}$. A. B. W.

574. Structure of the Elements. A. Dauvillier. (Comptes Rendus, 173. pp. 1458-1461, Dec. 27, 1921.)—This paper deals with a study of the fine structure of the X-ray spectra of a number of miscellaneous elements, the bearing of the X-ray data on the atomic structure being considered in each case. The following elements are mentioned: Gold, antimony, cerium, tin, uranium. A. B. W.

575. Corpuscular Spectra and their Use in the Study of X-Ray Spectra. M. de Broglie. (Comptes Rendus, 173. pp. 1157-1160, Dec. 5, 1921.)—The author indicates the possibility of predicting the detailed spectra of X-rays from the results of a study of the corpuscular spectra of the secondary β -rays, produced when the X-rays are incident on the element under consideration. This can be accomplished merely by applying the quantum relation indicated in the paper. The spectra of X-rays can, therefore, be studied without the use of a crystal. The elements Ur, Th, Bi, Pb, Hg, and Ba have been studied from the point of view of their L, M, etc., "centres" excited by means of a Coolidge tube. Some of the results obtained will form the subject of a further paper. A. B. W.

576. Corpuscular Spectra of the Elements. M. and L. de Broglie. (Comptes Rendus, 173. pp. 527-529, Sept. 26, 1921.)—Since the publication of a former note on this subject [Abs. 1078 (1921)] by one of the authors, an important paper by Ellis [Abs. 1782 (1921)] has appeared. This paper supports the deductions previously made in respect of the laws of the corpuscular radiations excited in the elements by X-rays. Ellis found that the magnetic spectra of secondary β -rays excited in some of the heavy metals by γ -rays, correspond to the energy of expulsion of the electrons from the K and L centres ("niveaux") of these atoms.

The authors now produce evidence to show that similar corpuscular radiations from heavy metals under X-radiation have been observed corresponding to the L, M, and N centres. A. B. W.

RADIO-ACTIVITY.

577. State of Products from RaEm in Water—Studied in Relation to the Phenomena of Absorption and Isotopy. **H. Lachs** and **H. Herszfinkel.** (*J. de Physique et le Radium*, 2. pp. 319–328, Oct., 1921.)—The state of radio-active bodies in water has been studied by Paneth and Godlewski. In the cases of RaA, RaB, and RaC, these observers conclude that observed facts are best explained by assuming that these bodies form colloidal solutions with the water.

The author now treats the same subject from a different point of view, namely, that of absorption and isotopy. A. B. W.

578. Radio-active Quantity Requiring a New Name. **N. E. Dorsey.** (*Washington Acad. Sci.*, J. 11. pp. 381–386, Oct. 4, 1921. From the Bureau of Standards.)—A suggestion is made that a new name is required for a unit “*r*” defined as follows:—

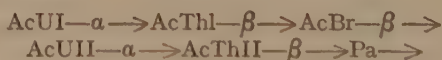
“An ‘*r*’ of any material is that amount of the material which will produce transformed atoms at the same rate as transformed atoms are produced by 1 gm. of radium.”

The value in gm. or in atoms of an “*r*” of any element depends upon the ratio of the transformation constant and of the atomic weight of the element to those of radium.

Illustrations are given of the advantages to be derived from such a unit, and the author suggests that it should be called a “rutherford.”

A. B. W.

579. A New Radio-active Substance. **A. Piccard** and **E. Stahel.** (*Phys. Zeits.* 23. p. 1., Jan. 1, 1922.)—In a previous paper one of the authors has proposed the following scheme of disintegration of the actinium series:



This involves the insertion between uranium and protactinium of two Th-isotopes of the Ac series. One of these, UY, has long been known; the other is now identified as a new substance discovered by the authors. A brief description is now given of the chemical processes involved in its preparation. A. B. W.

580. Range and Ionisation of α -Particles from RaC and ThC. **G. H. Henderson.** (*Phil. Mag.* 42. pp. 538–551, Oct., 1921.)—An investigation of the ionisation curves of RaC, ThC₁, and ThC₂ in air, is described, particular attention being paid to the end portions of these curves. It is shown that a considerable portion of each of these curves is a straight line. A theoretical interpretation of the end of the ionisation curve is given and the following equations in the cases of the various α -particles are obtained:

$$\begin{array}{l} \text{RaC } \alpha\text{-particles } I = 3.53(6.592 - x), \\ \text{ThC}_1 \alpha\text{-particles } I = 3.47(4.529 - x), \end{array}$$

if the maximum of the curve be taken as unity. The values of “extrapolated ranges” in cm. are given in the table below for air at 760 mm.

pressure and 0°, 15°, and 20° C. temperature. The ranges were measured by the "constant-distance, ranging-pressure" method.

RANGES IN AIR.

	0° C.	15° C.	20° C.
RaC {	6.592 (6.70)	6.953 (7.04)	7.074 (7.19)
ThC ₁ {	4.529 (4.59)	4.778 (4.84)	4.861 (4.93)
ThC ₂ {	8.167 (8.27)	8.616 (8.72)	8.714 (8.87)

The values given in brackets are those generally accepted and are inserted for the sake of comparison with the values now obtained by the author. It is considered that the error involved in the unbracketed values is less than 1 in 2000 for RaC and ThC₂ and less than 1 in 1000 for ThC₁. The accuracy in the ordinary ranges (bracketed) is considered to be of the order of 0.3 %. The range of RaC α -particles in air is given by Bragg as 7.14 cm. at 20° C.

A. B. W.

581. Scattering of γ -Rays from RaC. J. Neukirchen. (Zeits. f. Physik, 6. 2. pp. 106-117, 1921.)—Describes a determination of the absorption and scattering-coefficients of RaC γ -rays in water, aluminium, glycerin, and turpentine. The following values are given for the mass-scattering coefficients.

Water	$\sigma/\rho = 0.0383 \pm 0.0005$
Aluminium	$\sigma/\rho = 0.0323 \pm 0.0004$
Glycerin	$\sigma/\rho = 0.0406 \pm 0.0009$
Turpentine	$\sigma/\rho = 0.0352 \pm 0.0005$

A. B. W.

582. Distribution of Radium Active Deposit in an Electric Field. W. Mund. (J. de Physique et le Radium, 2. pp. 378-383, Dec., 1921.)—The author describes a continuation of experiments made by H. W. Schmidt [see Abs. 842 (1908)] on this subject. As a result of his measurements of the distribution of active deposit on two parallel plates at known p.d.'s he obtains a formula expressing the percentage deposit on either plate and the variation of this amount with voltage.

A. B. W.

583. Decay Constant of Radium Emanation. W. Bothe and G. Lechner. (Zeits. f. Physik, 5. 5 and 6. pp. 335-340, 1921. From the Physikal.-Techn. Reichsanstalt.)—The decay constant of RaEm has been determined and found to be 1 % greater than the Curie-Rutherford value. The paper contains a useful table of the decay and growth of RaEm. The final value of T, the half-value constant, is given as $T = 3.810$ days, or $\lambda = 0.1819 \text{ day}^{-1} = 2.106 \times 10^{-6} \text{ sec.}^{-1}$.

A. B. W.

584. *Two Direct Methods of Determining the Ranges of α -Particles in Liquids and Gases.* **H. v. Trautenberg** and **K. Philipp.** (Zeits. f. Physik, 5. 5 and 6. pp. 404-409, 1921.)—An ingenious method is described for measuring the range of α -particles in liquids. The liquid is contained in a vessel consisting of three similar cylinders in hydrostatic connection. In one of these cylinders is partially immersed a solid cylindrical rod which serves as a rough adjustment of the liquid level in the three cylinders. In the second cylinder a thinner cylindrical rod (of known volume per unit length) is partially immersed and can be raised and lowered by a fine screw adjustment with graduated head. This rod serves as a fine calibrated adjustment of the height of the liquid level. In the third cylinder are arranged the active source beneath the liquid surface and also a zinc sulphide screen just above the surface. It is at once evident how this system can be employed to determine the thickness of liquid layer required to stop the α -particles. In the case of water the α -rays from RaC are completely absorbed in a layer 60.0μ in thickness.

An apparatus, analogous to those designed by Bragg and Taylor, is also described for the measurement of ranges of α -particles in gases. For a description of this, reference should be made to the original paper.

A. B. W.

585. *Retardation of α -Particles in Elements and Compound Substances.* **H. v. Trautenberg.** (Zeits. f. Physik, 5. 5 and 6. pp. 396-403, 1921.)—A theoretical paper dealing with the retardation of α -particles in their passage through matter. The theory is based mainly on the observations of W. H. Bragg on the absorption of α -particles by matter.

A. B. W.

HEAT.

586. *Measurement of Small Temperature Variations by the Ultra-Micrometer.* **W. Sucksmith.** (Phil. Mag. 43. pp. 223-226, Jan., 1922).—A modified form of Whiddington's ultra-micrometer [Abs. 1350 (1920)] was used to measure small changes in the temperature of a copper tube which carried one plate of a condenser. Changes in the condenser capacity due to variations of the length of the copper tube were detected as in Whiddington's arrangement by changes in the note produced in the telephones. The copper tube was heated electrically by means of a constantan wire concentric with the tube, and the tube was insulated from the invar end-pieces by short lengths of quartz tube. The arrangement was found to be capable of detecting a change in temperature of about $1/16000$ of a degree Centigrade. A. W.

587. *Piezoelectric Method of Measuring Explosion Pressures.* **D. A. Keys.** (Phil. Mag. 42. pp. 473-488, Oct., 1921).—This paper contains the results of some experiments on the measurement of the time-pressure relations when mixtures of electrolytic gas and air are detonated at constant volume, and when small charges of gun-cotton and T.N.T. are detonated in water. In measuring very rapid changes in pressure it is necessary to have the inertia of the moving parts of the recording system as small as possible. Especially is this true when changes of pressure amounting to several hundred pounds per sq. inch take place in a ten-thousandth of a second. To overcome this source of error and to measure pressure changes in very small intervals of time, J. J. Thomson devised the method employed in the experiments now described. The method consists in the application of the piezoelectric properties of tourmaline crystals in conjunction with a special form of kathode-ray oscillograph. Crystals of tourmaline properly cut and mounted are placed in the vicinity of the explosion, where the time-pressure curve is to be determined. The variation of the electrical charge acquired by the crystals under the influence of the pressure is measured by means of the kathode-ray oscillograph. Since the charge separated on tourmaline is directly proportional to the pressure applied, we have a convenient method of obtaining exceedingly rapid pressure-changes in terms of variation in electrical charge. The amount of the charge is measured by the deflection of a beam of kathode rays which passes between two parallel condenser plates that receive the charge separated on the crystals. An alternating magnetic field of known frequency gives a time displacement of the beam perpendicular to the displacement due to the electric field. The kathode rays fall directly on a photographic plate, and a charge-time record is thus obtained. Full details of the experimental arrangements and results are given. Generally speaking, the results show a rapid rise in pressure to a maximum after about 0.001 sec., followed by a less rapid fall of pressure, the curve approximating to a logarithmic curve. Typical examples of such curves are given. Measurements with two sets of apparatus at a known distance apart gave a result for the velocity of propagation of explosion waves in water slightly higher than that of sound. All the results were obtained in the immediate neighbourhood of the explosion. A. W.

588. *Determination of the Thermal Conductivity, Specific Heat, Density, and Thermal Expansion of Different Rocks and Refractory Materials.* **Y. Tadokoro.** (Tôhoku Univ., Sci. Reports, 10. pp. 339-410, Dec., 1921.)—More than 100 different materials have been tested at ordinary temperatures, while in the case of refractory materials such as bricks, cements, and porcelains, the thermal conductivity, etc., have been measured at temperatures up to 1000° C. Many tables, curves, and diagrams are given to exhibit the results obtained.

The thermal conductivity was measured by obtaining a sinusoidal periodic source of heat by periodically varying the resistance of a special construction placed in the circuit containing a heater, by means of a crank motion driven by a water-wheel at constant speed. If R_1 , R_2 , and ϵ_1 , ϵ_2 , be the amplitudes and phases of the temperature wave at depths x_1 and x_2 , the diffusibility $k = K/\rho c = \pi(x_1 - x_2)^2/T(\log R_1/R_2)^2 = \pi(x_1 - x_2)^2/T(\epsilon_1 - \epsilon_2)^2$, where K is the thermal conductivity, ρ the density, and c the specific heat. K was also measured independently by heating a cylindrical specimen by an electric current passing through its axis. The results showed very good agreement.

Specific heats were measured by the usual method of mixtures. Densities at temperatures up to 1000° C. were calculated from the measured coefficients of expansion of the specimens. A novel method was employed for measuring this expansion, three silica tubes of lengths differing by a constant amount a being inserted to different depths parallel to the axis of the specimen, the ends of these tubes causing rotation of three mirrors, from which the linear expansion was deduced. If α_s and α_g denote the expansion coefficients of specimen and silica tube, it is shown that $\alpha_s - \alpha_g = (\delta l_1 - \delta l_3)/2a(t - t_0)$, δl being the distance moved through by a silica tube, and t , t_0 the temperatures. Amongst other interesting results it is found that the conductivities of magnesia and red bricks decrease with rise of temperature, while those of chrome, silica, and "shamotte" bricks increase at first, and then decrease. Chemical analyses are given for each specimen. **T. B.**

589. *On the Coefficients of Pressure and Expansion of Helium, Hydrogen, and Nitrogen.* **F. Henning and W. Heuse.** (Zeits. f. Physik, 5. 5 and 6. pp. 285-314, 1921. From the Physikal.-Techn. Reichsanstalt.)—The most important measurements of the expansion and pressure coefficients α and β of pure gases were made by P. Chappuis (Trav. et Mém. du Bureau des Poids et Mesures, 6 and 13) in the case of hydrogen and nitrogen, with the object of fixing the temperature scale of the Bureau International. These measurements also formed the basis for the determination of the absolute temperature. T_0 of the melting-point of ice which is connected with the limiting value γ of the coefficients at the melting-point pressure $p_0 = 0$ by the relation $\gamma = \lim_{p_0=0} \alpha = \lim_{p_0=0} \beta = \frac{1}{T_0}$ if dissociation be neglected. Hitherto the assumed values were $\gamma = 0.003618$, and $T_0 = 273.09$. Since Chappuis conducted these investigations, helium has been largely used as a thermometric substance especially at very low temperatures where it has displaced hydrogen. As the result of a series of observations at the Reichsanstalt [see Abs. 1998 (1921)] with a helium thermometer, a value for the pressure coefficient of this gas was obtained which was not in agreement with the abs. temp. T_0 of the ice-point. Fresh fundamental measurements were therefore made by the authors on the

two coefficients for He, H, and N between the pressures p_0 of 0.2 and 1.1 metres of mercury. From these measurements it follows that the values of γ and T_0 are 0.0036604 and 273.20° respectively. A very full description is given of the apparatus used, the method of preparing the gases and filling the thermometer, together with tables of results and a full investigation of all corrections and their probable errors. Results are given in the following form :—

$$\begin{aligned}\text{Helium} \quad & \dots 10^7\alpha = 36,604 - 19p_0; \quad 10^7\beta = 36,604 - 4p_0 \\ \text{Hydrogen} \quad & \dots 10^7\alpha = 36,604 - 12p_0; \quad 10^7\beta = 36,604 + 17p_0 \\ \text{Nitrogen} \quad & \dots 10^7\alpha = 36,604 + 127p_0; \quad 10^7\beta = 36,604 + 134p_0\end{aligned}$$

The values for α and β for H and N differ from those of Chappuis by only about 1 part in 10,000. T. B.

590. Total Emissive Power and Resistivity of Tungsten at Incandescence. **A. G. Worthing** and **W. E. Forsythe.** (Phys. Rev. 18. pp. 144–146, Aug., 1921.)—Describes the results of experiments on the connection between emissivity, resistivity, and temperature in the case of tungsten filaments, using lamps in which end-losses were minimised by the use of fine potential-wires attached at either end of the middle third of the filament. It was found that to great accuracy the following equations hold : $R/R_0 = (T/T_0)^{1.200}$ and $\log E = 3.680 (\log T - 3.3) - 1040/T + 1.900$, where E is the emissivity in watts per cm., R is the resistance and T is in degrees K. It is considered that deviations from the second equation do not exceed that due to a temperature error of 0.5 deg. K., while the first equation also holds to very great accuracy over the range of incandescent temperatures up to 2700° K. It appears also to hold for temperatures up to 3200° K. Using as the value of the Stefan-Boltzmann constant 5.72×10^{-12} watt/cm.² deg.⁴ and the temperature scale for tungsten adopted by the General Electric Co. (U.S.A.), the following values of emissive power are obtained for tungsten :—

T.	E (Tungsten).	E' (Black Body).	E/E'.
1000	0.57	5.72	0.100
1500	5.64	29.0	0.194
2000	24.2	91.5	0.264
2500	69.8	223	0.313
3000	161	463	0.347
3500	317	858	0.369

The exponent in the first equation given above differs for different lamps, according as the filament is thoriated or not, and depending also on the previous history of the filament. J. W. T. W.

591. Action of a Magnetic Field on the Flow of Heat. **O. M. Corbino.** (Accad. Lincei, Atti, 30. ii. pp. 7–10, July, 1921.)—The paper consists chiefly of a discussion of the effect of a magnetic field on the flow of heat in a conductor when the latter has the special form of a circular disc heated

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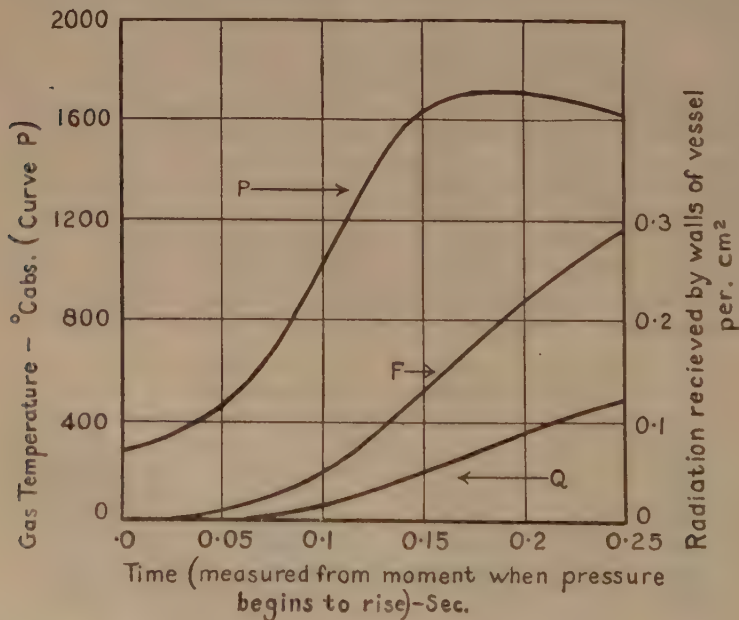
at the centre. The treatment is mathematical and cannot be usefully abstracted, but a line of experimental investigation is indicated for the demonstration of the effect.

J. W. T. W.

592. New Fixed Point on the Thermometric Scale. F. Bates and F. P. Phelps. (Phys. Rev. 18. pp. 115-116, Aug., 1921. Paper read before the Am. Phys. Soc.)—When crystalline quartz is heated, recrystallisation takes place between 570° – 575° C. Energy changes are found to occur with great suddenness at the critical point when the crystal is absorbing energy. This fact may be made use of in order to standardise a thermo-couple for this part of the temperature scale. The couple is inserted in a small opening within the crystal, which is then slowly heated. On plotting voltage against time, an extremely sharp break is observed at 573.3° C. A maximum variation of only 0.2 deg. C. was found in a large number of determinations, using quartz from various parts of the world.

T. B.

593. Radiation Emitted in Gaseous Explosions. W. T. David. (Phil. Mag. 42. pp. 868-870, Nov., 1921.)—The results of the experiments here



dealt with are summarised in the accompanying curves, exhibiting the radiation transmitted through a plate of fluorite (highly transparent to all infra-red radiation down to about 11μ) and a plate of quartz (transparent to infra-red radiation down to about 3.5μ only), respectively, corresponding to the rate of rise of pressure, or gas temperature, shown by the curve P. The results go to show that the more vigorously combustion proceeds, the greater the proportion of short-wavelength (infra-red) radiation emitted, and therefore the greater the proportion of energy acquired during the period covered by the vibratory degrees of

freedom corresponding to the short-wave radiation relatively to that acquired by those degrees corresponding to radiation of greater wavelength. They therefore tend to confirm the theory, tentatively suggested in a former paper [Abs. 405 (1920)], that when combustion is gentle the intramolecular energy acquired by the freshly formed molecules during combustion is, so long as this is gentle, concentrated in the rotational degrees of freedom and in such very low-frequency vibrations as the molecules may be capable of executing, but as the combustion increases in vigour the higher frequency vibrations begin to share in the energy. The author stated, further, that such a theory would serve to explain many of the phenomena of the pre-pressure and explosion periods in coal-gas and air explosions.

G. W. DE T.

594. Measurement of Temperatures below 0° C. F. Henning. (Zeits. Elektrochem. 27. pp. 494-496, Nov. 1, 1921. From the Physikal.-Techn. Reichsanstalt.)—The theoretical foundation for the measurement of all temperatures is the thermodynamic scale, or the scale of an ideal gas with fundamental points 0° and 100°. The constant-volume helium gas-thermometer is usually employed as the primary instrument of temperature measurement. The following fixed points below 0° C. have been determined in the Reichsanstalt:—F.P. of mercury -38.89° ; of CO_2 , $-78.52 + 1.595 \times 10^{-2}(p - 760) - 1.1 \times 10^{-5}(p - 760)^2$; B.P. of hydrogen, $-252.80 + 0.45 \times 10^{-2}(p - 760)$; B.P. of oxygen, $-182.97 + 1.258 \times 10^{-2}(p - 760) - 0.79 \times 10^{-5}(p - 760)^2$. Here T_0 is taken as -273.20° , as calculated from the coefficients of pressure and expansion α_0 and β_0 and the relation $-\frac{1}{T_0} = \lim_{p \rightarrow 0} \alpha = \lim_{p \rightarrow 0} \beta = 0.0036604$.

Of all secondary thermometers for measurement of temperatures below 0°, the platinum-resistance thermometer is the most suitable and the most accurate. The calibration below -40° is not very simple. It has been deduced that the relations $R = r/r_0$ and $R' = r'/r'_0$ at t° and 0° different Pt thermometers are followed, as well as the Nernst relation $R = R' + M(R' - 1) + N(R' - 1)^2$, where M and N are constants to be determined by comparison with a gas thermometer. For temperatures between -193° and -257° a rather simple formula has been found to apply to a particular thermometer in the Reichsanstalt, namely: $\log(R - 0.003798) = -1.69978 + 0.756055 \log T - 35.3843/T$. One advantage of the Pt thermometer is its increased sensitiveness at low temperatures, e.g., 0.01 deg. change in temperature at 0° gives a change in resistance of about 4×10^{-5} ; at -190° , 2×10^{-4} ; and at -253° , 1×10^{-3} . Liquid thermometers can be used only within narrow limits with an accuracy of perhaps $\frac{1}{10}$ deg.; thermo-elements (Cu-constantan or Fe-constantan), down to about -190° with the same limits of accuracy.

The vapour-pressure thermometer was introduced as a practical instrument by Stock in 1906. It combines simplicity of observation with accuracy, as the vapour pressure of a liquid changes very rapidly with temperature. Determination of saturation pressures of substances with low boiling-points, have recently been made by Stock and the author, some of the substances with corresponding normal B.P.'s being SO_2 , (-9.99°) ; NH_3 (-33.36°) ; CO_2 (-78.52°) ; HCl (-85.03°) ; PH_3 (-87.43°) ; C_2H_4 (-103.72°) ; CH_4 (-161.37°) . Tables are given of values of the constants A, B, C , of the Nernst formula $\log p = -A/T$

+1.75 log $T - B \times T + C$, connecting the saturation pressure p with the abs. temp. T of the above substances. T. B.

595. Disappearing Filament Optical Pyrometer Free from Diffraction Effects at the Filament. C. O. Fairchild. (Phys. Rev. 18. pp. 116-118, Aug., 1921. Paper read before the Am. Phys. Soc.)

596. Isentropic Transformations of Saturated Vapours (Water-Vapour and SO₂). U. Bordoni. (N. Cimento, 22. pp. 246-277, Nov.-Dec., 1921.)—A mathematical treatment of the problem of isentropic variations in a system consisting of a liquid in contact with its vapour. The calculated values of γ_1 (the specific heat without change of state) at various temperatures agree well with those found experimentally in the case of SO₂. The second part of the paper deals with slow isentropic changes involving change of state, while the third part deals with slow isentropic changes of p and v . At the end of the paper are given tables for the amount of change of state under given conditions of temperature and pressure in the cases of water-vapour and SO₂, and for the change of volume in the case of water-vapour. J. W. T. W.

597. Ultimate Rational Units ; Calculation of Entropy. G. N. Lewis. (Phys. Rev. 18. p. 121, Aug., 1921.)—Shows that in Sackur's equation for the entropy of a monatomic gas, namely $S = R \log_e KT^{3/2}VM^{3/2}$, if M be the mass and V the volume per molecule, then K becomes unity instead of a constant of nature, and hence the entropy can be calculated with very great accuracy by working back from this equation. J. W. T. W.

598. On the Classification Problem of Radiation Theory for Two Kinds of Individuals, reduced to Symmetrical Form. I. K. Lichtenecker. (Phys. Zeits. 23. pp. 43-44, Jan. 15, 1922.)—The combination formula for k spheres distributed in u places plays an important part for the basis of the radiation theory. This formula is $C = (u + k - 1) / k! (u - 1) ! = (u + k - 1) / k$, where the number C is the possibility of the above distribution. This formula has been assigned a useful part by Ehrenfest and Onnes [see Abs. 716 (1915)], and the present author now seeks to put it into a clearer form for use in the radiation theory. It is shown that the number of arrangements of k spheres between t separate places is equal to the number of t -place arrangements to which k spheres can be assigned. The theorem is then extended to spheres of two different kinds, and the result found that the number of arrangements now becomes $(u + k) / k$. This is then applied to the physical problem of the energy-quanta.

H. H. Ho.

599. Dynamical Quantum Weight. Molecular Symmetry and Ferro-Magnetism. W. Schottky. (Phys. Zeits. 23. pp. 9-13, Jan. 1, 1922.)—The present paper is supplementary to an earlier communication on the same subject [see Abs. 684 (1921)], and deals first with some corrections necessitated by the publication of recent papers by Ehrenfest on molecular symmetry and by Lenz on the theory of para- and ferro-magnetism. The author finds it necessary to correct his statement of the deviations of the observed chemical constants from that calculated on the Nernst theorem. This chemical constant is evaluated by Stern for atmospheric pressure and using Briggs's logarithms as -1.588 , while the observed

values are -1.62 for Hg, -1.65 for Ar, and -1.69 for H_2 . The deviations are therefore -0.03 , -0.06 , -0.10 , and not positive as previously recorded. It appears that the deviations are in all cases so small that the normal value may be ascribed to these substances, and only in the case of hydrogen which has an experimental value of -1.69 ± 0.15 do other considerations play a part. The paper then discusses molecular symmetry in connection with Ehrenfest's paper. The section concludes with some remarks on the problem of the quantum weight of the atom in the lowest quantum state which do not stand in direct connection with considerations hitherto advanced. It appears as if the empirical quantum weight 1 for argon and mercury, as also for zinc and cadmium, is not to be explained on properties due to symmetry. The final section is devoted to para- and ferro-magnetism, wherein Lenz's recent paper is discussed. The problem is considered of an orientation-change taking place at ordinary or low temperatures, and not merely at high temperatures, whereby in certain cases a practical contradiction to the Nernst theorem may arise. For this purpose an investigation into para- and ferro-magnetism is made. Two facts are of importance, namely, that with certain paramagnetic salts there has been observed a continuity and normal temperature dependence down to the lowest measurable temperatures. The quantum significance of this phenomenon is discussed, as also the transition point for ferromagnetic bodies. In general the transition from completely reciprocal orientation of the quantum orbits in neighbouring atoms to a partial re-orientation at low temperatures provides an explanation of the transition points of solid bodies at these temperatures. The Nernst theorem is opined to be inadequate for explaining the multiplicity of theoretical and experimental problems that arise.

H. H. Ho.

SOUND.

600. *New Experiments with the Telegraphone.* **A. Nasarischwily.** (Elekt. Zeits. 42. p. 1068, Sept. 22, 1921.)—By the help of photographs and diagrams, the author describes the amplification of telephonic messages by a triode valve and its application to signalling to a locomotive engine-driver, the rail serving as the moving magnetisable member upon which the telephonic messages are telegraphically recorded. E. H. B.

601. *The Organ Pipe as a Coupled System.* **A. T. Jones.** (Phys. Rev. 18. pp. 118–120, Aug., 1921. Paper read before the Am. Phys. Soc.)—The flue (or flute) organ pipe has a series of natural frequencies; the wind striking the upper lip of the pipe produces an edge tone, and the tones from the tube and the upper lip react upon each other. The pitch of the edge tone depends upon the blowing pressure, and various observers have found that this pitch rises with increasing pressure, that the pitch is usually discontinuous at certain points, and that similar statements hold for organ pipes. [See Abs. 1119 (1921).] The present author's experiments confirm these views and show that if the pipe may be treated as a coupled system, and if the coupling is rather loose, then the experimentally obtained graphs (in which frequency of pipe is plotted against that of edge tone) are of the general form to be expected. E. H. B.

602. *Sound Speeds in Air and Hydrogen.* **E. Grüneisen and E. Merkel.** (Ann. d. Physik, 66. 5. pp. 344–364, Jan. 10, 1922. From the Physikal.-Techn. Reichsanstalt.)—The Thiesen method of closed cylinder resonator with use of a valve transmitter and telephone as source of sound was critically examined. It was thus found that an end correction was needed.

The speed of sound in air was found to be 331·57 m. per sec.; that in hydrogen, 1260·6 m. per sec. The following values were found for the ratio of the specific heats: in air, 1·403₄; in hydrogen, 1·408 (0° C.; 1 atmo.). [See Abs. 90 and 828 (1908).] E. H. B.

603. *Phonic Turbine.* **Z. Carrière.** (J. de Physique et le Radium, 2. pp. 337–344, Nov., 1921. Ann. de Physique, 17. pp. 337–344, Nov., 1921.)—Describes a phonic wheel in which the drive and regulation are automatically due to the glancing of the current of air upon a number of prisms or wedges on the wheel itself. Its application to organ pipes is explained in detail by aid of diagrams. E. H. B.

604. *Binaural Audition of Pure Sounds.* **A. Lo Surdo.** (Accad. Lincei, Atti, 30. i. pp. 125–128, Feb. 20, 1921.)—Experiments proving by means of the sound-interference apparatus that our perception of the direction of noises and sounds of low frequency is due to the difference in the time taken by the vibratory pulsations to reach the ears. Any source of sound may be used, provided the sounds produced be not of higher frequency than the limit of perception of phase difference. Beyond this limit the difference in the distance travelled between the two ears is more than half a wave-length, therefore any one position of the source

no longer corresponds to a difference of phase. The upper limit of frequency giving the phase effect being probably not the same for all individuals, it would be interesting to ascertain whether in animals, which are presumably sensitive to phase effect, this limit is higher when the auricular distance is less than in the human being. E. F.

605. Speed of Sound in Hot Gases and Ratio of Specific Heats. **H. B. Dixon, C. Campbell, and A. Parker.** (Roy. Soc., Proc. 100. pp. 1 26, Oct. 4, 1921.)—These experiments have been conducted on gases in tubes by means of an electric chronograph, the temperatures ranging from 0° C. to 600 or 1000° C. The following are the chief experimental results; the speeds in free gas were then calculated.

MEAN SPEEDS OF SOUND IN GASES IN LEAD, STEEL, AND SILICA TUBES.

Temperature.	Nitrogen.	Air.	Carbon Dioxide.	Methane.
° C.	metres/sec.	metres/sec.	metres/sec.	metres/sec.
0	334·4	328·6	256·6	425·2
100	389·1	382·5	297·9	481·8
200	436·4	429·2	333·4	532·5
300	478·6	470·5	364·7	577·9
400	516·8	508·1	392·9	618·9
500	551·8	542·6	419·1	657·2
600	584·3	574·6	443·0	692·6
700	615·1	604·6	—	—
800	643·7	—	—	—
900	671·0	—	—	—
1000	696·8	—	—	—

The graphs plotted with speeds as ordinates and temperatures as abscissæ are all similar in slope and are all slightly convex upwards.

E. H. B.

606. New Electric Arrangement for Photography of Sound Waves. **C. J. Petropoulos.** (J. de Physique et le Radium, 2. pp. 317-318, Oct., 1921.)—This arrangement is a still further improvement of that due to Toepler and Foucault and modified by Wood and by Mach, and is designed for the photography of sound-waves emitted on the passage of an electric spark. It consists of a pair of coupled electric circuits as detailed in a diagram, the loose coupling being variable at will. Two reproductions are given of the effects obtained. E. H. B.

607. Acoustic Pressure Distributions, Chiefly in Reservoirs and Pipes. **C. Barus.** (Nat. Acad. Sci., Proc. 7. pp. 207-213, July, 1921.)—A preliminary notice of the work concerning which a full account is to appear shortly. The method depends on the author's use of displacement interferometry. The present paper gives diagrams of the apparatus and a number of graphs. E. H. B.

608. Protection against Sounds. **Marage.** (Comptes Rendus, 173. pp. 1016-1019, Nov. 21, 1921.)—Discusses the possible ways of cutting off irritating and undesirable sounds. The conclusions reached are as

follows:—(1) The ear is sensitive to high sounds and to those out of tune, but much less sensitive to low sounds. (2) Vibrations are as injurious to the nerves as are microbes to the general health. (3) To protect the ears we should (i) stop the vibrations through the air and the ground, (ii) modify the source of sound, or (iii) modify the reception at the ear by diverting attention from the disagreeable vibrations. E. H. B.

609. *Sounds of Splashes.* A. L. Narayan. (Phil. Mag. 42. pp. 773–775, Nov., 1921.)—Following up the work of C. V. Raman and A. Dey on the distinction between the silent and noisy splash, the present paper deals with its dependence on the speed of entry of the falling sphere into the water. Vibration records are taken (and eight are photographically reproduced) of the sound on entry. These show that the speed from a height of 146 cm. is critical for the sphere in use. A height of 151 cm. gives a much louder sound, 152·5 cm. is still better. A photograph of the whole experimental arrangement is included in the paper. E. H. B.

610. *Atmospheric Wave due to the Oppau Explosion.* L. Fabry. (Comptes Rendus, 173. pp. 567–568, Oct. 10, 1921.)—The records of two barographs at Marseilles for the day of the explosion, Sept. 21, 1921, show an irregularity at 8h. 4m. G.M.T. consisting of a sudden rise and fall of about 0·5 mm. The author is not sure whether the time of the explosion (7h. 30m.) stated in papers in his possession is G.M.T. or Central European time. If the former, then the interval of 34 m. is consistent with the travel of a wave, with the speed of sound, from Oppau to Marseilles, but otherwise the speed would be much less than that of sound. No effect was recorded by the seismographs.

[In the Meteorological Office, London, the time was understood to be 7h. 32m. Central European time.—ABTRACTOR.] M. A. G.

611. *Unusual Bell at Wehlen.* J. Biehle. (Phys. Zeits. 22. pp. 337–338, June 1, 1921.)—Quite contrary to the ordinary state of things as to the sequence of the separate tones in a church bell, the large bell of the tower in Wehlen shows the following series when the ground tone is reduced to 100 per sec. :—

5 overtone	339·7	1 overtone	134·0
4 overtone	294·2	Clapper tone.....	113·3
3 overtone	226·4	Ground tone.....	100·0
2 overtone	175·2	Under-tone	61·6

E. H. B.

612. *Notation for Musical Scales and that due to A. von Oettingen.* J. Würschmidt. (Zeits. f. Physik, 5. 1. pp. 111–120, 1921.)—This paper follows a previous one by the same author [see Abs. 897 (1921)] and discusses further his system of using letters of the alphabet for the notes of the diatonic scales of C major and other signs derived from these by the additions of the syllables *is* and *es* for the sharpening and flattening, respectively, by a chromatic semitone. The syllables are doubled for double sharps and flats, and various bars above or underlinings are adopted to express in the different systems the intervals of commas. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

613. *Charges Apparently Smaller than the Electronic Charge.* **R. Bär.** (Phys. Zeits. 22. pp. 615-617; Disc., 617-618, Nov. 1 and 15, 1921. Paper read at the Deut. Physikertag. Jena, Sept., 1921.)—Explains to some extent why Ehrenhaft's experiment led to the supposition that charges smaller than the electronic charge had been discovered. R. Fürth, Ehrenhaft, Lenard, and Gerlach joined in the discussion, in which it seemed agreed that sub-electrons had not yet emerged. E. H. B.

614. *Measurement of Charge on Fog-Particles at Pressures from 1 to 9 Atmospheres.* **K. Wolter.** (Zeits. f. Physik, 6. 5 and 6. pp. 339-351, 1921.)—Describes an interesting investigation of the electrical charges carried by fog-particles, as in the determination of e by the Millikan-Ehrenhaft method. This method depends for its accuracy on the reliability of the Cunningham correction to Stokes' law for the fall of a small particle in a viscous medium. Experiments are described in which the drops carrying the elementary charges are formed of (1) paraffin oil, (2) mercury, (3) platinum particles, (4) copper particles, and (5) sulphur particles. All the observations lead to the conclusion that the value of e , the elementary charge, is 4.8×10^{-10} e.s. unit; further, that the Stokes-Cunningham law holds good regardless of whether the experiment is made at atmospheric or higher pressures. A. B. W.

615. *Electrical Doublet Theory of the Molecular Forces of Interaction.* **R. D. Kleeman.** (Phys. Rev. 18. pp. 303-312, Oct., 1921.)—The author has previously found from data on the internal heat of evaporation of liquids that the attraction between two atoms is proportional to the product of the square roots of their atomic weights. It is now suggested that a neutral atom with a positive nucleus surrounded by electrons is an electrical doublet; and it is shown that the force between two such doublets would on the average be an attraction proportional to the product of the moments of the two doublets. This result combined with the previous one leads to the conclusion that the *electrical moment of an atom* is proportional to the square root of its atomic weight. Similarly the electrical moment of a molecule comes out equal to the sum of the moments of the component atoms. This theory of molecular attraction is supported by the fact that the *stopping power of gases for α -rays* is known to be proportional to the sum of the square roots of the atomic weights of the component atoms; for this law follows directly if we suppose the transfer of energy from the α -particles to the gas molecules occurs solely as a result of electrical forces exerted by the charged rays on the molecular doublets. AUTHOR.

616. *A Generalisation of Electrodynamics; Applications to the Structure of the Electron and to Non-Radiating Orbits.* **L. Page.** (Phys. Rev. 18. VOL. XXV.—A.—1922.

pp. 292-302, Oct., 1921.)—*Generalisation of Electrodynamics*.—If every element of charge is assumed to be the centre of equal electric and magnetic fields, each of which is capable of rotation, the electromagnetic equations assume a symmetrical form, containing Lorentz's formulation of Maxwell's equations as a special case.

Structure of the Electron.—If the electric field of each element of charge on the surface of the Lorentz electron is supposed to rotate about the normal to the surface, a magnetic field is produced which just annuls the intrinsic field due to the magnetic charge assumed to be distributed over the surface, and which exerts an inward stress equal to the outward stress of electrostatic repulsion. Not only is the surface in equilibrium, but the equilibrium is found to be stable for small volume changes.

Non-Radiating Electronic Orbits.—A suitable rotation of the fields of the elementary charges constituting the electron about an axis parallel to the acceleration would cause the radiation term to vanish. This suggests the possibility of radiationless orbits. AUTHOR.

617. Electrostriction in Gases ; Determination of Electrical Moment of Dipolar Molecules. O. E. Frivold. (Phys. Zeits. 22. pp. 603-610, Nov. 1 and 15, 1921.)—The attractive forces between the molecules of a gas sets up an internal pressure which may be increased by the application of an electric field. A very small contraction of volume is thereby caused which is denominated electrostriction and which can be employed in determining the electrical moment of the dipoles. The dipolar gas investigated was SO_2 . An expression is first worked out for the moment of the SO_2 dipole in terms of the contraction in a cylindrical condenser at a given temperature. The experimental method and apparatus are described, including a special micromanometer, and results are given for three series of measurements which finally give the electrical moment as 1.83×10^{-18} . Previous values obtained were 1.76×10^{-18} (Jona), and 1.60×10^{-18} (Bädecker). G. E. A.

618. The Relativity Problem in Dielectrics. E. Carvallo. (Comptes Rendus, 173. pp. 1461-1463, Dec. 27, 1921.)—In the case of a dielectric such as ebonite, of which the specific inductive capacity K is about double that of air, the e.m.f. induced by its movement will be that of a metal multiplied by a coefficient λ lying between 0 and 1, to be determined by experiment. According to Lorentz's theory $\lambda = (K - 1)/K$, this being the value required to account for the partial convection of light waves in Fizeau's experiment and in agreement with Fresnel's formula. Assume axes fixed relatively to the inducing magnetic field, and suppose the dielectric to move with velocity v in the direction Ox . Then the e.m.f. induced in it will involve the introduction of the term $\lambda v (\partial b / \partial y + \partial c / \partial z)$, and it is easily seen that a transformation from the original axes to a system moving uniformly with respect to them will leave the form of the equation unchanged, the terms in λv disappearing in virtue of Faraday's law of electromagnetic induction. Therefore, if a dielectric with coefficient of induction λ , receive an electromagnetic wave from a fixed source relatively to which it is moving with velocity v , the equation of wave-propagation will be the same as if they were relatively at rest. That is to say, the dielectric moving with velocity v drags with it the waves with a velocity λv , where $\lambda = (K - 1)/K$. If the motion be in an electric field, we have to introduce a term in λ into Maxwell's

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second equation, and a magnetomotive force comes into play in place of the e.m.f., and is added to that arising from the displacement currents. The existence of such forces was experimentally verified by Röntgen and recorded in 1885.

G. W. DE T.

619. *Electromagnetism and the Principle of Relativity.* E. Carvallo. (Comptes Rendus, 173. pp. 1155–1157, Dec. 5, 1921.)—The law of induced e.m.f. in a conducting element which moves in a magnetic field was extended by Bouty to electrolytes, and a vectorial term was introduced into the electromagnetic equations, the importance of which was pointed out by the author [Abs. 1120 (1902)]. He again draws attention to the importance of this term in the problem of relativity, and shows that the electromagnetic equations remain unchanged for translational motion of the body, provided that only conductors and electrolytes are in its neighbourhood. This invariance is not retained for a change of variables which expresses the rotation of the system of axes. In the problem of relativity, these results would signify that in a world formed of electrolytes and conductors, no electromagnetic phenomena would disclose its motion of translation, but its rotation could be demonstrated. Reference is made to the experiments of Michelson (1881) and Sagnac [Abs. 1506 (1914)], in connection with the inclusion of dielectric bodies by the theory. This accomplished, harmony would be established between electromagnetic theory and experiment without the necessity of abandoning the usual ideas of length and time.

G. E. A.

620. *The Plane Wave in an Isotropic Dielectric.* S. Ray. (Phys. Rev. 18. pp. 377–379, Nov., 1921.)—*Electric and Magnetic Forces in the Direction of Propagation of a Plane Wave in an Isotropic Dielectric* need not be zero if the ether has a constant electric density P_e and a constant magnetic density P_m , for it is shown that these forces are equal, respectively, to $P_e\lambda/k$ and $P_m\lambda/\mu$ where λ , k , and μ denote wave-length, inductivity, and permeability respectively.

AUTHOR.

621. *Electromagnetic Field of a Radiating Slightly-Damped Antenna.* R. Schachenmeier. (Phys. Zeits. 22. pp. 676–679, Dec. 15, 1921. Paper read at the Deut. Physikertag. Jena, Sept., 1921. Zeits. techn. Physik, 2. No. 11. pp. 330–333, 1921.)—Derives certain mathematical formulæ for calculating the natural wave-length of the antenna.

E. H. B.

622. *Fundamental Equations of the Electron Theory.* U. Doi. (Phys. Math. Soc. Japan, Proc. 3. pp. 150–165, Nov., 1921.)—A study of the five fundamental equations of Lorentz's electron theory in relation to the basic experimental laws of electromagnetism.

A. B. C. L.

623. *Present Status of Electric and Magnetic Units.* J. H. Dellinger. (Phys. Rev. 18. pp. 121–125, Aug., 1921. Paper read before the Am. Phys. Soc.)—A general discussion of the present position as regards the internationally accepted units, namely: the ohm, ampere, volt, coulomb, farad, and henry. The magnetic units, with the exception of the maxwell, have not received the same international sanction, and the American I.E.E. Standards Committee is pressing for the adoption of the gilbert, gauss, and oersted. A table is given showing the alternative set of magnetic units adopted in magnetic engineering calculations, and based

on the ampere-turn instead of the gilbert. The conversion ratios are also given in this table. J. W. T. W.

624. *Summary of Observations of Atmospheric Electricity at Seeham (Salzburg) during the Summers of 1916 to 1920.* **E. Schweidler.** (Akad. Wiss. Wien, Ber. 129. 2A. Nos. 9 and 10. pp. 919-927, 1920.)—The period 1908 to 1915 has already been dealt with in the same journal [see Abs. 453 (1919)]. The present contribution summarises observations of conductivity, potential gradient, vertical current, and ionisation in a closed vessel for the further period of five years, in particular in relation to meteorological conditions, with results in general agreement with those of the former period. M. A. G.

625. *Maintenance of the Negative Discharge : the Fundamental Problem of Atmo-electrical Research.* **E. Schweidler.** (Ann. d. Physik, 63. 8. pp. 726-738, Dec. 10, 1920.)—This paper refers to R. Seeliger's, bearing a similar title (*ibid.*, 62. p. 464, 1920), and discusses Ebert's theory, the hypothesis of negative corpuscular radiation and a simplified scheme of possible theories. Finally the experimental ways in which the problem may be rendered more clearly understood are set forth. L. H. W.

DISCHARGE AND OSCILLATIONS.

626. *Conductivity of Flames Containing Salt Vapours.* **A. B. Bryan.** (Phys. Rev. 18. pp. 275-291, Oct., 1921.)—*Conductivity as a Function of the Concentration.*—The method used is due to H. A. Wilson. The ratio of the potential gradients in the central parts of two flames, each about 7 cm. wide, through which the same current was passed, was determined by means of a quadrant electrometer connected alternately to each of two pairs of probe wires in the flames, by means of a rotating commutator. Both flames were sprayed with identical sprayers. When desired for greater sensitiveness the current through the flames could be increased by applying K_2CO_3 to the cathodes. Using the conductivity produced by distilled water as a standard, the relative conductivities of various concentrations of *potassium carbonate, sodium carbonate, caesium chloride, calcium chloride, barium chloride, aluminium chloride, and boric acid* were determined. For the last four the conductivity was found to be approximately proportional to the cube root of the concentration, whereas in the case of the others the relation is more complicated. A theory to account for the cube root relation is suggested. The conductivities due to *mixtures of two solutions* were found to agree with the values computed from the conductivities due to the components alone. *Uranium nitrate* gave little or no conductivity. AUTHOR.

627. *Temperature Effect in Barium and Strontium Photoelectric Cells.* **T. W. Case.** (Phys. Rev. 18. pp. 413-414, Nov., 1921.)—*Photoelectric Current from Treated Barium and Strontium Surfaces.*—A metal plate mounted in an evacuated cell was outgassed by heating inductively and was then coated with barium or strontium. The large temperature effect previously reported was confirmed. At a dull red heat the current from the two metals was found to be respectively 1200 and 25 times as great as at room temperature. AUTHOR.

628. Effect of Age and Concentration of Rhodamine-B upon the Photoelectric Current Developed. **R. Y. Jenkins.** (Phys. Rev. 18, pp. 402-412, Nov., 1921.)—Two identical semi-transparent films of Pt, both sputtered on one piece of glass and baked at 500° C., were used as electrodes of a cell into which various solutions of rhodamine-B in alcohol were successively introduced. For a fresh solution, the photoelectric current developed by illuminating one electrode was found to increase with time to a steady value. The sensitiveness was decreased by exposure to room light, but recovered in the dark. With increasing concentration the sensitiveness increased to a maximum for 3 % solution and then decreased. The current-time curves obtained with intermittent illumination vary in form with the concentration, showing saturation for low concentrations, reaching maxima for concentrations of 1 to 3 % and increasing indefinitely for higher concentrations. These and other observations show that the phenomenon is quite complicated.

Relative Conductivity of Solutions of Rhodamine-B in Alcohol was measured for concentrations up to 8 %.

Effect of a Flowing Electrolyte upon the Potentials of the Electrodes for a Solution of Rhodamine-B in Alcohol.—The Pt electrode against which the electrolyte flowed became negative with respect to the other, the effect being proportional to the rate of flow. AUTHOR.

629. Photo-Thermionic Currents from Oxide-Coated Filaments. **H. D. Arnold and H. E. Ives.** (Nat. Acad. Sci., Proc. 7, pp. 323-325, Dec., 1921.)—Case and Merritt have recently described experiments in which the oxide-coated filament of an audion is subjected to illumination, with the result of increasing the current between filament and plate [see Phys. Rev. 17, p. 398 and p. 525, 1921]. Merritt showed that in his experiments the added space current was principally due to short-wave radiation, and was dependent on the filament temperature. This might be taken to indicate that the emission of photo-electrons is a function of the temperature of the surface, which disagrees with conclusions drawn from experiments upon other photoelectrically active materials. In recent experiments by the authors it has been found that this effect has characteristics sufficiently different from those of the true photoelectric effect to raise doubts as to the identity of the two phenomena. If they are not identical, then the new effect is not necessarily evidence for a dependence of the photoelectric effect on temperature. The experiments were concerned with the rate of growth and decay of the light-induced additions to the space currents. These were recorded on a string galvanometer through a distortionless amplifier system. With light transmitted through a deep-red glass the growth and decay of the added space currents was just the same as for a sudden brief increase in the filament current. In both cases the curves have the general appearance of heating and cooling curves. With a blue glass screen transmitting no red the behaviour is essentially different. Whereas with red light the added space current continually increases with filament temperature, with blue light the added current at first increases and then starts to decrease. At low temperatures the growth and decay are exceedingly slow. With blue light the rates of growth and decay increase as the temperature of the filament is raised, until at the highest temperature used the response is practically instantaneous. The existence of the slow response and its variation with temperature would appear to differentiate this effect from

the true photoelectric effect, which, as far as previously known, is instantaneous at all temperatures. The true nature of the increased electronic emission under blue illumination is not decided by these experiments, but several possible explanations are suggested. A. W.

630. Photoelectric Effect as a Function of Gas-Content. M. Sende and H. Simon. (Ann. d. Physik, 65. 8. pp. 697-719, Oct. 13, 1921.)—An account is given of an investigation of the relative effects of absorbed gas and the pure metal on the photoelectric emission from metallic surfaces under the action of ultra-violet light from a mercury-vapour lamp. The authors come to the conclusion that 99.9 % of the observed photoelectric effect is due to gas in the metal surface; the effect from the pure "degassed" metal is consequently negligible. A. B. W.

631. Comparison of Processes of Ionisation which give rise to Currents in Gases. E. W. B. Gill. (Phil. Mag. 42. pp. 852-856, Nov., 1921.)—An experimental verification of the theory of ionisation by collision given by Townsend depends principally on the comparison of the currents obtained between parallel plates, with the formula for these currents calculated on the hypothesis that all the new ions are generated in the gas by collisions of electrons or positive ions with molecules of the gas. The author now describes a series of experiments which have an important bearing on the theory. A. B. W.

632. Contribution towards a Theory of Formation of Strata in Gases. H. Kost. (Zeits. f. Physik, 6. 3. pp. 213-214, 1921.)—In the current theories of stratification put forward by Stark and Seeliger, the necessity is absent for considering why ionisation under certain conditions in the positive glow region must lead to stratification and not so under other circumstances. The author has repeated two earlier investigations on pure hydrogen, and now discusses the conditions for stratification. Carriers of light-emission are molecules, atoms, atomic ions, and molecular ions, and the percentage of each present depends on the state of dissociation of the gas. For the formation of strata it is necessary for atomic ions to be present in preponderating amount, and with gaseous mixtures combinations with molecular ions have to be taken into account. The positive carrier must also combine so that over a definite length of path equal falls in potential take place. A further dependent condition is that the velocity which an ion receives under the potential gradient must stand in quite a definite relationship to the velocity of the electron concerned. The sum of these velocity energies must be just equal to the necessary energy for light-emission. Experimental details of the discharge tube are discussed, and the effect of alteration of stratification is described. Deviation by a magnetic field is considered. It was found impossible to standardise strata movements by means of a rotating mirror. Stratification is found to be a result of collision between particles of varying magnitude, and, in the purest gases, is particularly suitable for spectral observation of the light-emission of ions. H. H. Ho.

633. Theory of Arc Generators of H.F. Currents. E. Mayer. (Zeits. techn. Physik, 2. pp. 18-28; 40-49; 73-81, and pp. 94-105, 1921.)—The treatment is mathematical and is illustrated with numerous curves which should be consulted in the original. The paper is of importance

in that it is here shown that there are three causes contributing to the known fact that in arc-generator installations the effective current in the antenna is $0.707 i_g$, where i_g is the direct-current intensity; in other words $J = i_g$. Further, in dealing with the efficiency of arc installations, it is pointed out that Liebowitz's conclusion that the max. efficiency obtainable is 50 % is incorrect owing to the fact that the energy which is supplied to the system when the arc is connected to the h.f. circuit is greater than when the arc circuit is disconnected. The efficiency, it is shown, can reach 66.6 %.

L. H. W.

634. *Vibration Forms and Phases of Components in Valve Transmitters.* E. Alberti and G. Zickner. (Phys. Zeits. 22, pp. 652-653, Dec. 1, 1921. From the Physikal.-Techn. Reichsanstalt.)—By use of Braun tubes a qualitative proof of the theoretical deductions as to curve forms and phase relations has been carried out with wave-lengths of 18,000, 6000, 2000, and 1000 metres. The experimental tests were made by the method of Lissajous' figures from the electric and magnetic deflection of kathode rays. E. H. B.

635. *The Damping of Two Electrostatically-Coupled Circuits.* W. Grösser. (Archiv f. Elektrot. 10, pp. 257-276, Nov. 15, 1921.)—The author deals with the damping of the oscillations in two electrically-coupled circuits in a manner analogous to that employed by Rogowski for two magnetically-coupled circuits [Abs. 1603 (1921)]. After establishing in a most general manner the definition of the "capacity coupling," the differential equations of two electrically-coupled circuits are obtained and rigorously solved for the case of zero resistances. For the case of resistances different from zero the solution is only approximated, as it is obtained by neglecting some small terms. The frequencies and dampings in the cases of electrically and magnetically coupled circuits are minutely analysed and compared.

E. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

636. *Temperature of an Electrically-Heated Filament.* C. Snow. (Phys. Rev. 18, pp. 158-160, Aug., 1921. Paper read before the Am. Phys. Soc.)—Long wires surrounded by air at various pressures, or by a finely-powdered material such as flour, were heated from 0° to about 600° C., the temperature coefficient of resistance and the thermal conductivity of the wire being considered as constant. The effect of the surrounding medium on the wire temperature could be accounted for by assuming the heat flow from wire to medium to be proportional to the difference of temperature between the wire and the nearest layer of the medium. Using this and the known conductivity of the wire, mathematical expressions have been found for the wire temperature at any point. Three cases have been considered: (1) Where the current was maintained constant; (2) the E.M.F. constant; (3) the time rate of heating of wire and medium with constant current. In the third case it was found that the wire temperature $U(t)$ at any point at time t and the corresponding temperature of the adjacent medium $V(t)$ were given by $U(t) = \{U(\infty)/b(a_1 - a_2)\} \{a_2(a_1 - b)(1 - e^{-a_1 t}) + a_1(b - a_2)(1 - e^{-a_2 t})\}$ and $V(t) = \{V(\infty)/(a_1 - a_2)\} \{a_1(1 - e^{-a_2 t}) - a_2(1 - e^{-a_1 t})\}$, where $U(\infty)$ and $V(\infty)$ are the final temperatures of wire and medium, and

α_1 , α_2 , and b are given functions of the thermal and electrical constants of the wire and of the thermal contact of wire and medium. T. B.

637. Discontinuity of Resistance Preceding Supra-Conductivity. P. W. Bridgman. (Washington Acad. Sci., J. 11. pp. 455-459, Nov. 19, 1921.)—Supra-conductivity has been observed at low temperatures in mercury, tin, thallium, and lead. This state is reached by a discontinuous change of resistance at a definite critical temperature, a change ascribed by the author to a polymorphic change of structure. The temperature of discontinuity is known to be depressed when a current in the conductor is increased, and also when the conductor is placed in a magnetic field. For the latter case, the change of temperature is estimated by means of an equation similar to Clapeyron's thermodynamic latent heat equation, and is tested with the aid of Onnes' data for lead. The calculated value for the normal transition temperature is 5.3 , Onnes' estimate being 6° abs. The temperature of transition of the four metals is depressed in a magnetic field; this means that the phase which is stable at the lower temperature has the greater susceptibility. G. E. A.

638. Variation of Metallic Conductivity with Electrostatic Charge. H. A. Perkins. (Phys. Rev. 18. pp. 131-133, Aug., 1921. Paper read before the Am. Phys. Soc.)—The conception of metallic conduction being based on moving electrons seems to justify the assumption that a negative charge should increase the conductivity of a circuit and a positive charge should decrease it. This was tested as follows: A primary coil of about 80 turns was wound upon a glass tube inside which fitted a smaller tube on which a secondary was wound. The primary was excited from a 60-cycle a.c. circuit. The secondary, carefully insulated throughout, included a moving-coil galvanometer, and was given an alternating charge from one terminal of a high-tension transformer giving about 5700 volts, the other terminal being earthed. The two coils wound upon glass acted as a condenser, so that a fairly large charge could be communicated to the insulated system. In operation the galvanometer was not affected by the charging potential, but the induced alternating current caused a slight vibration of the "spot" on the scale, and if the current reached too high a value (say 3 milliamps.) produced a small deflection always in the same direction. If, however, the induced current and the charging potential were both present, a deflection of about 30 scale divisions was obtained, indicating a direct current of about half a micro-amp. This phenomenon behaved in a regular manner, and reversed if the phase of the e.m.f. were reversed by interchanging the terminals of the transformer. A change of phase of less than 180° produced proportional changes in the reading. Simple theory is given from which it is calculated that for the circuit used the effective velocity of the electrons was 8800 cm. per sec. in the case of a current of 4.4×10^{-7} amp. A. W.

639. Self-Inductance of Solenoids of Rectangular Shape. A. Esau. (Jahrb. d. drahtl. Tele. 18. pp. 453-457, Dec., 1921.)—Niwa has given a simple formula for calculating the self-inductance of square coils, and the applicability of this formula is examined in the present paper. The formula is $L = 4\pi nza^2F$, where a is the length of the side of the square, n is the total number of turns, z is the number of turns per unit length, and F is a function of δ , the ratio of the length of side to the

length of the coil. It is shown that Niwa's formula gives good results so long as the value of δ does not exceed 20-25 and the expression g/d (where g is the depth of winding and d the wire diameter) is not greater than 4-6. For greater values of g/d accurate results are only obtained with smaller values of δ . For shorter coils and greater depth of winding the author's formula [Abs. 149 (1920)] must be used, that of Niwa being no longer valid for such conditions. A. W.

640. Graphical Determination of Self-Inductance. J. Hak. (Zeits. Math. u. Mechanik, 1. pp. 227-230, June, 1921.)—A graphical method is described, illustrated by numerous diagrams, for determining the self-inductance of straight cylindrical conductors of any form of cross-section. The method makes use of the function $\iint \log zdF dF' = F^2 \log g$, where dF and dF' are two elements of the surface F , and z is their distance apart. The inductance of a straight conductor of any given section is equal to the mutual inductance of two infinite parallel filaments whose distance apart is the distance g defined above. A. W.

641. Calculation of Inductance of Circular Coils of Rectangular Cross-Section. F. W. Grover. (Phys. Rev. 18. pp. 136-139, Aug., 1921. Paper read before the Am. Phys. Soc.)—To make rapid calculations possible with an accuracy better than 0.1 %, the author has calculated for the Bureau of Standards constants which cover the whole range of possible coils. On account of the difficulties in the reproduction of curves to give the accuracy desired, it has seemed advisable to present the results in the form of tables. The calculation of the inductance using these tables is based on the use of two formulæ :

- (A) $L = 0.002\pi^2(2a/b)n^2aK' = 0.002\pi^2(2a/b)n^2a(K' - dk)$ microhenrys,
 (B) $L = 0.001n^2aP' = 0.001n^2aPf$ microhenrys,

where L = inductance with uniform distribution of the current, a = mean radius of coil, b = axial dimension of the cross-section, c = radial dimension of the cross-section, n = total number of turns. The quantities K' , P' , dk , and f are functions of the two parameters $c/2a$ and b/c or c/b . The values in the tables are given for values of b/c or c/b in steps of 0.1, and for $c/2a$ in steps of 0.1 with the added values of 0.025 and 0.05. Formula (A) is specially useful for relatively long coils, while (B) applies best to pancake coils, but both may be used in any case. A. W.

642. Distributed Capacity of Inductance Coils. G. Breit. (Phys. Rev. 18. pp. 133-135, Aug., 1921.)—If a condenser of capacity C is connected across the terminals of a coil the resulting circuit resonates to a certain frequency $\omega/2\pi$. Experiments show that in most cases it is possible to find such numbers L , C_0 that $L(C + C_0) = 1/\omega^2$. The constant C_0 , if it exists, is called the "effective capacity" of the coil. A formula has been derived for the calculation of the effective capacity of a coil. The formula is $C_0 = \int_{x_1}^{x_2} [M(x)/L \{ \int_1^x \alpha(x)/L \cdot dx \}] dx$, where x is an arbitrary parameter along the wire, $\alpha(x) = Q(x)/(di_1/dt)$, $Q(x)dx$ is the charge between x and $(x + dx)$, i_1 is the current at the end of the coil, L the self-inductance, and $M(x)dx$ the mutual inductance of the element dx to the rest of the

coil. The formula has been applied to a number of different cases and verified experimentally. Formulæ are given for the different types of coil dealt with. A. W.

643. Inductance and Capacity of Single-Layer Coils. J. Wallot. (Archiv f. Elektrot. 10. pp. 233-256, Nov. 15, 1921.)—The inductance and capacity of single-layer coils were measured by inserting them in a Lecher system of parallel wires in which stationary waves were generated. When the coils are inserted in the potential antinode, i.e. at the free ends of the wires, the new position of the bridge gives a measure of their capacity. When the coils are inserted in the potential node, the bridge-shifting affords a measure of their inductance. Two equal coils were used at the same time, each in a wire of the Lecher system, in order to maintain symmetry, their mutual actions being taken into account. The precautions taken for these measurements are carefully explained. The results of the experiments show that the Strasser formula for the inductance of a single-layer coil is not quite exact for two reasons: firstly, because this formula is applicable only to short coils, and secondly because it does not take into account the distribution of the current inside the wire. The values of the capacity given by the experiments are sufficiently in agreement with those given by the Drude and Göthe formulæ. The author concludes that the capacity of a coil is not generally a quality proper to the coil, but is the capacity with respect to other bodies, in particular to the earth. For not too small a pitch the capacity of coils depends chiefly upon their diameters and lengths. The author, therefore, does not admit the existence of a critical frequency, function of the inductance and capacity of each turn. E. B.

644. Carborundum and its Rectification Effect. H. M. Dowsett. (Radio Rev. 2. pp. 582-594, Nov., and pp. 642-659, Dec., 1921.)—The chemical and physical nature of carborundum is first dealt with. A description is then given of a long series of experiments carried out in order to elucidate the rectification effect. The following points were treated: (1) Influence of the nature of the wide-area contact at the base of the crystal on the characteristic curve, both with negative and positive crystals. (2) Effect of contact pressure at the crystal point. (3) Variation of rectification effect with position in the block from which the crystal is taken. (4) Effect of atmosphere. (5) Effect of temperature. (6) Effect of overload, such as the momentary application of high voltage. All the results obtained are represented graphically. A theory of the rectification effect in carborundum is given, and finally a model of the carborundum molecule is sketched, which would have the properties required to bring about the reactions described in the paper. A. W.

645. Thermo-Element for Material Radiation. A. Rüttenauer. (Zeits. f. Physik, 5. 5 and 6. pp. 341-348, 1921.)—The conditions for the greatest possible sensitiveness of a vacuum-thermoelement used for the measurement of radiation have been investigated by E. S. Johansen [(Abs. 1759 1910)]. In the present paper the conditions which determine the sensitiveness of a vacuum-thermoelement exposed to material rays are considered, and the proper thickness and length of the wires or strips, and the size of the intercepting surface as depending on the

electrical and thermal conductivity of the thermo-element and on the radiation are investigated. The conditions which determine the sluggishness of a thermo-element are also considered, as well as the means for sheltering the junctions very thoroughly from outside disturbances. The theoretical investigation of these points leads up to the following practical considerations which are of importance with regard to the construction of the thermo-element:—(1) If the resistance of the galvanometer is given and unchangeable, the resistance of the thermo-wires must be equal to the galvanometer resistance. The surface of the intercepting plate of the junction must be as large as the bundle of rays. The thickness of the plate is to be chosen the smaller, the smaller the slowness of action of the thermo-element is required to be. (2) If the galvanometer resistance is changeable, then that resistance or the double face of the junction may be arbitrarily chosen, but the surface of the junction must not be greater than the cross-section of the material bundle of rays. If the slowness of action is to be as small as possible, then the surface of the junction should be made small and the galvanometer resistance great. But here also the galvanometer resistance must be equal to the resistance of the thermo-wires. (3) If the winding of the galvanometer is unchangeable but its resistance changeable through parallel or series connection of the coils the galvanometer resistance is to be made as small as possible and the surface of the junction to be taken as large as the cross-section of the bundle of rays permits. Only when the lagging of the thermo-element can be no more lessened by reduction of the thickness of the plate of the junction is the surface of the junction to be kept within smaller limits, the galvanometer resistance being made equal to the resistance of the thermo-wires. (4) Thin wires are preferable to strips; the reflection capacity of the junctions and wires should be as high as possible. The junctions exposed to rays and those not so exposed are to be so arranged as to be, as far as possible, free from outside disturbances.

J. J. S.

646. *New Form of Thermogalvanometer.* A. Campetti. (N. Cimento, 22. pp. 321–322, Nov.–Dec., 1921.)—Describes a simplified form of thermogalvanometer in which the magnetic system of an ordinary Deprez-d'Arsonval galvanometer is employed. The moving part consists of two loops in series, one consisting of two thick wires of different metals, the second of two very fine wires of the same metal. The two loops are joined in series so that when the current passes through them, the heat produced in the fine-wire loop, owing to its ohmic resistance, produces a difference of temperature between the two ends of the thick-wire loop. This causes a thermoelectric current to flow round the loop, superimposed on the main current, and thus a deflection is caused. A sensitivity of 1 mm. per milliamp. is attainable with single loops, but the same principle can be applied when multiple loops are used. If one of the metals used in the thermoelectric loop be iron, it is necessary to compensate for the inequality produced in the magnetic field.

J. W. T. W.

647. *Electrometer under Pressure.* P. Mercier. (Arch. des Sciences, 3. pp. 585–589, Nov.–Dec., 1921.)—A modified form of the electrometer under pressure originated by Guye has been described in an account of research on the discharge in nitrogen at high pressures [Abs. 190 (1922)]. The apparatus is based on the mutual repulsion of bodies raised to the

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same electrical potential. In the actual model an Al needle, movable about a horizontal axis, is repelled by a fixed vertical plate whose plane passes through the axis of the needle. From the lower end of the needle is suspended a small pan in which extra weights may be placed. A copper cylinder surrounds the whole to screen it from electrostatic effects. The present paper discusses the different factors which affect the indications of the instrument. It is concluded that the needle should be light; its centre of gravity should not be too far distant from the axis of rotation and should be as nearly as possible in the line joining the point of suspension of the extra weights to the axis. Further, comparative measurements for very small differences in inclination of the needle should be avoided.

A. W.

ALTERNATING CURRENTS AND MAGNETISM.

648. *Dependence of the Temperature Coefficient of a Permanent Magnet on its Dimensions.* **K. Honda and T. Matumura.** (Tôhoku Univ., Sci. Reports, 10. pp. 417-421, Dec., 1921. Fifty-third Report from Iron and Steel Research Inst.)—The intensity of a permanent magnet varies with change of temperature in a reversible way. Investigations with regard to this have been made by Cancani, Ashworth, and Gumlich [Abs. 155 (1920)]. Gumlich concluded that the temperature coefficient, although dependent on dimensions, could not be ascribed to polar displacement. The present authors, from considerations of the molecular theory of magnetism, attribute the dependency of the coefficient on the dimensions to the demagnetising effects of the ends, and are led to the conclusion that the magnitude of the coefficient should increase linearly with increase of the demagnetising force. This result has been confirmed experimentally. A permanent cylindrical magnet (length 20 cm., diam. 5 mm.) was placed in a heating coil, and its temperature raised by steps up to 100° C. and then diminished. Changes in the moment were measured simultaneously by the magnetometer method, and the temperature coefficient was deduced. The magnet was carried through similar temperature cycles when subjected to applied magnetising fields of varying magnitude and acting either in the direction of or against, the demagnetising field of the magnet. No appreciable temperature hysteresis was observed. The temperature coefficient when the resultant of the applied and demagnetising field is zero or the magnet is infinitely long, is characteristic of the nature of the magnetic material. For the magnet investigated the temperature coefficient varies linearly from -2.05×10^{-4} for zero resultant field to -2.42×10^{-4} for a resultant field of -27.92 gauss. The demagnetising field of the magnet was -14.02 gauss. L. L.

649. *Spectrum of Magnetic Permeability of Iron in the Region of Wave-Lengths 1 cm. to 1 kilometre.* **W. Arkadiev.** (Phys. Zeits. 22. pp. 511-513, Sept. 15, 1921.)—In 1911 the author measured the absorption of electric waves by two parallel wires, and found that μ for iron and nickel varies with the wave-length, the values being 3.6 and 0.85 respectively for $\lambda = 1.3$ cm., and, for $\lambda = 72.7$ cm., 78 to 92 for iron and 20 for nickel. This disappearance of ferromagnetic property at low wave-lengths is explained by the author as due to the natural vibrations of the elementary magnets, and conclusions were drawn as to the natural periods, damping, dimensions, and friction of these magnets. Later measurements have

been made by Kartschagin, Theodortschick and Wwedensky, and a composite curve is given of the variation of μ with λ over the range 1 cm. to 1 km. It is concluded that the elementary magnets in iron have several natural periods of vibration.

G. E. A.

650. *Change of Resistance of Bismuth Films in a Magnetic Field.* **L. F. Curtiss.** (Phys. Rev. 18. pp. 255-274, Oct., 1921.)—*Ageing of Sputtered Bismuth Films.*—The films sputtered on glass between sputtered gold terminals, were sealed in glass tubes and kept *in vacuo* at 210–220° C. for a number of hours. As a result each film showed a gradual decrease of resistance amounting in all to about 40 %. Eventually the films became so thoroughly aged that temperature-resistance measurements *in vacuo* could be accurately reproduced over long periods.

Increase of Resistance in a Magnetic Field for Temperatures from –190° to 230° C.—The isothermal curves obtained for each film by varying the field up to 18,000 gauss, have the same form for all temperatures, differing only by constant factors, and closely resemble the corresponding curves for bismuth in bulk. The percentage increase of resistance is not proportional to the square of the field. It is greater the lower the temperature and the lower the resistance, that is, the thicker the film, reaching a value about 1/5 that of bismuth for the thickest film tested.

Variation of Resistance with Temperature, –190° to 230° C.—The curves are parabolic in form, showing a minimum around 150–200° C.; the lower the resistance of the film, the lower the temperature of minimum resistance.

AUTHOR.

651. *The Barkhausen Effect in Relation to Hysteresis and Crystalline Structure.* **W. Gerlach and P. Lertes.** (Phys. Zeits. 22. pp. 568–569; Disc., 569, Oct. 1 and 15, 1921. Paper read at the Deut. Physiker-tag., Jena, Sept., 1921.)—The noise which accompanies the magnetisation of iron, described in a previous paper [see Abs. 1834 (1921)], is made the subject of further investigation. The effect is greater the softer the iron; but thermal treatment of the same material diminishes the above effect at the same time as the hysteresis loss. This holds for electrolytic iron, wrought iron, and steel. Two pieces of transformer iron of the same material but subjected to different thermal treatments gave effects which were in about the same proportion as the respective watt losses. The parts played by coercive force and remanence are not yet known. As regards the crystalline structure, the magnitude of the hysteresis loss is directly connected with the size of the crystallites, but, on the other hand, the above effect diminishes with increasing size of the crystallites. The effects caused by two blocks of 4 % silicon iron, one crystalline, the other non-crystalline, are compared.

G. E. A.

652. *Susceptibility of Zinc-Iron Alloys of Low Iron-Content.* **E. Lehmann.** (Phys. Zeits. 22. pp. 601–603, Nov. 1 and 15, 1921.)—Alloys were tested with iron up to 8.5 % by Overbeck's method with bifilar suspension in a non-homogeneous field. The results show that the susceptibility is independent of the field strength within the observed range of concentration; it attains a max. value of 30×10^{-6} for 7.29 % iron. It seems doubtful whether the structure is so simple as that indi-

cated by thermal analysis. The character of the results is unaltered by rise of temperature from 18° to 160° . [See also Abs. 1335 (1910).]

G. E. A.

653. *The Law of Eötvös Concerning Terrestrial Gravity and Magnetic Force.* **L. Steiner.** (Terrest. Magn. 26. pp. 81-90, Sept., 1921.)—As to the origin of local magnetic disturbances on the earth's surface there are two rival concepts. In the first, these are considered to be due to disturbances of the earth currents due to irregularities in the earth's crust; in the second, they are considered as due to varying magnetisation of the earth's crust caused by local effects of strata on the earth's magnetic field. The latter theory has the greater weight of experimental evidence.

Eötvös has worked out the equations which link together local magnetic variation and local gravity variation. The reasoning and the results are given in this paper. One important conclusion attained from the reasoning is that "the magnetic force exerted by a mass is not proportional to its force of attraction, but to the gradient of the force."

Another set of equations gives the connection between the magnetic forces and those quantities which can be measured directly with the well-known torsion balance of Eötvös.

The author works out a simple case. He supposes a disturbing mass in the earth's crust to have the form of a rectangular prism which stretches in one direction to infinity, and finds the disturbing forces of gravity and the magnetic disturbing forces on certain assumptions as to the density and permeability of the prism. As an appendix he gives some formulæ for the attractions of rectangles and parallelepipeds of finite size.

P. E. S.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

654. *On the Use of Constant Voltages in Radiographic Diagnosis.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 173. pp. 382-384, Aug. 16, 1921.)—Reference is made to two previous papers [Abs. 726 (1916), 1312 (1921)] concerning the Coolidge and Lilienfeld tubes. Values for the time of exposures required, for equal results, with the Coolidge tube with (1) constant current, (2) sine-form current, and (3) interrupted sine-form currents, are given, and similar comparisons for the Coolidge, Lilienfeld, and Müller tubes. The Lilienfeld requires the shortest exposure, but is more complicated than the Müller tube. The Coolidge tube is simple, but requires a longer exposure than the Lilienfeld or Müller tubes. The fact that the German tubes have a platinum antikathode and the Coolidge tube one of tungsten does not cause a difference of more than 5%. The results are the same with a screen, and do not vary with the voltages used.

B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

655. Sorptive Capacity of Charcoal. Sorption of Ammonia by Coconut Charcoal. J. B. Firth. (Chem. Soc., J. 119. pp. 926-931, June, 1921.)—Variations in results obtained in previous investigations are referred to, e.g., the case of the sorption of hydrogen by coconut charcoal at liquid air temperatures [see Abs. 2126 (1906)]. Experiments are described showing the effect of previous heating at various temperatures over various periods on the sorptive capacity of charcoal. Coconut charcoal carbonised at as low a temperature as possible and then heated at 600°-900° C. increases considerably in activity within certain limits, this treatment also increasing the density. When the charcoal has been strongly heated the density increases, but the sorptive capacity diminishes. The results obtained are given in tabular form and are plotted. The equilibrium pressures at 18°, 0°, and - 20° are recorded. A. B. C. L.

656. Adsorption of Oxygen by Charcoal. H. H. Lowry and G. A. Hulett. (Am. Chem. Soc., J. 42. pp. 1393-1419, July, 1920.)—1. The anomalous behaviour of the adsorption of oxygen by charcoal extending over long periods of time, overlooked by recent investigators, has been confirmed. This is shown to be due to the presence of two phenomena, adsorption and surface combination.

2. A method has been developed for heating charcoal in a vacuum out of contact of oxygen-containing materials, such as quartz, to high temperatures by use of the Northrup induction furnace. The gases evolved were collected and analysed.

3. The formation of a carbon-oxygen complex, essentially a stable solid oxide of carbon, has been shown to occur on the surface of charcoal at ordinary temperatures. This complex decomposes on heating to CO₂ and CO, and can thus be considered to be an intermediate step in the combustion of charcoal, which supports the view suggested by Armstrong and supported with experimental evidence by Rhead and Wheeler and by Langmuir. The amount of oxygen thus combined with the charcoal has been found, in two samples of charcoal, to vary from 1.71 % to 3.75 % of the weight of the charcoal. AUTHOR.

657. Preparation of Pure Platinum. E. Wichers. (Am. Chem. Soc., J. 43. pp. 1268-1273, June, 1921.)—The methods used to prepare highly purified platinum are described, but it has not been found possible to obtain a sample of the metal quite free from calcium, although the percentage of the latter probably did not exceed 0.0001. T. H. P.

658. Compressibility of Brasses within the Range 20° to 800° C. F. Doerinkel and J. Trockels. (Zeits. f. Metallkunde, 12. pp. 340-358, Oct., 1920, and 13. pp. 305-315, July, 1921. Engineering, 112. p. 770, Dec. 2, 1921.)—Two series of tests were made at the Hirsch Messingwerk, A.G., near Eberswalde, on an Amsler machine. In the first series the load was determined which is required at different temperatures to reduce
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the height of specimens, 36 mm. high, 18 mm. in diameter, to one-half, without giving rise to fracture; in the second series the max. admissible compression is determined. All the specimens were tempered under conditions not specified. Instead of compressing exactly to half the height, a load of 10,000 kg. is applied in the first series, which was always sufficient and mostly not too great, and the 50 % value is deduced diagrammatically, in kg.-m., from the pressure curve drawn by the ram. Each test takes about 20 seconds. The specimen is heated within a cup of Roechling steel, wide enough to admit of the flattening out of the specimen; the bottom of the cup has a thickness of 21 mm. and a steel plate of the same thickness is put on the top of the specimen; the cup did not suffer, nor did the contact between the hot brass and the steel affect the experiments. To avoid heat losses the cup with the specimen in it is, during the test, surrounded by an electric furnace; this furnace consists of a gas-pipe of steel, 90 mm. internal diameter, which is coated with a paste of powdered firebrick and sodium silicate and dried. Three coats are applied; chrome-nickel wire is then coiled round the pipe, and the whole is inserted into a cartridge case and packed with powdered firebrick. The heat produced by the compression more than compensated for the heat losses; at 500° C. the temperature, as determined by thermocouples and calorimeter tests, was about 35 deg. higher at the end of the experiment. Such temperature determinations were not made at temperatures below 500°; steam heating was used below 100°. The specimens consisted of electrolytic copper and alloys with zinc containing about 88, 85, 72, 67, 63, 58 % of Cu with fractions of a per cent. of Pb and Fe; further a bronze (Cu with 1 % of Sn) and a condenser brass (68 Cu and 0.78 Sn); most of the materials were taken from rolled sheet metal, a few from compressed rods. The tests were first made between 500° and 800°, and subsequently between 20° and 800°. The results are given in tables and curves. In pure copper the resistance to compression decreases fairly regularly as the temperature is raised. In the tombak (with 85 Cu) the resistance falls off rapidly between 400° and 500°; in the brass of 72 % this decline sets in at 300°, in the 67 brass below 300°. The brass 58 could not be tested below 100°. Above 500° the alloys rich in copper require higher pressures to effect the same compressions than do alloys poorer in copper; below 300° the relation is reversed, whilst brasses 72 and 67 can more easily be rolled and drawn in the cold than brass 63; these operations, however, depend upon the ease with which the cross-section can be reduced. The rapid decline in the resistance to compression somewhere between 300° and 500° is common to all the alloys. When the work to be done in compression is plotted against the copper percentage, all the curves show a maximum. This, at low temperatures, up to 300°, lies at 67 % Cu and shifts over to 85 % at higher temperatures; at 500° this curve, so far irregular, becomes regular.

In the second series of tests the compression was continued until the specimen broke, as indicated by a diaphragm gauge, and the experiment was then repeated with smaller pressures. Copper may be compressed by 71 % of its original height at 20° and by 92 % at 800°, the curve being almost a straight line. The alloys gave less regular curves, the max. compression rising from about 55 % to 85 %. The values for the brass 63 were lower throughout than those for the other alloys, and the curve, moreover, has a minimum of about 53 % at 300°. The brass 58 is still more irregular, and the maximum compression of 80 %

can be borne at 700° (not 800° or at a higher temperature), the curve bending down again. This observation confirms the results of the tests of the first series. The temperature of 300° generally (copper and tombak excepted) marks the point at which the compressibility and the max. pressure admissible distinctly increase with rising temperature. The experiments suggest that the phenomena for the α range of brass are not fully understood as yet. Reference is made to the experiments by Doerinckel and Werner (Zeits. anorg. Chem. 115. pp. 1-48, 1921) on the specific heats of these alloys for the same temperature-range.

H. B.

659. Rate of Corrosion of Aluminium. **G. H. Bailey.** (Soc. Chem. Ind., J. 39. pp. 118-120 T., May 15, 1920.)—The mere alteration of weight is not a trustworthy criterion. In 10 years' experiments the author finds the corrosion per deg. per 100 cm.² of surface equal to $9(S + w - W)/8$, where W is the weight of the sheet employed, w its weight after exposure, and S is the weight of the precipitate obtained after ignition. In the curves the log. of the corrosion is plotted against the concentration of the solution, mostly at 12°. Caustic potash, soda, and baryta give straight lines; in ammonia the corrosion rises with concentration to a maximum, then to fall off. This happens also in sulphuric and nitric acids; in other acids the corrosion is fairly steady up to concentrations of 0.3 N; in HCl the corrosion increases rapidly afterwards. At higher temperatures near 100° the attack increases, and colloidal solutions may be formed. The corrosion is negligible in air, oxygen, CO, CO₂, Cl, H₂S; also in organic substances like acetene, alcohol (alcoholic beverages), antiseptics, benzol, citric acid, ether, oils and fats (if free from mineral acid), glycerin, gelatine; perhaps also in aqueous solutions of many salts of alkalis and alkaline earths as long as neutral. Corrosion takes place in aqueous solutions of salts of Cu, Fe, Hg, Ag, Pb, in caustic hydroxides and sodium chloride. The protective film forms more rapidly in impure than in pure metal. In ammonia this film, though of a thickness of 0.01 mm. only, has high insulating power against high-tension currents.

H. B.

660. Retarded Solution and Premature Precipitation of Cementite in Eutectic and Hyper-eutectic Carbon Steels. **Sauvageot.** (Comptes Rendus, 173, pp. 297-300, Aug. 1, 1921.)—A eutectic carbon steel, which had previously been annealed so that in places masses of cementite occurred surrounded by ferrite in addition to coarse pearlite, showed on heating for 5 minutes at 800° C. undissolved carbide, and 850° C. was required for complete solution in 5 mins. Even then diffusion had not equalised the carbon content throughout the mass, and, on cooling, the cement re-precipitated from the high-carbon areas before the A₁ 1, 2, 3 point. By heating to 900° C. diffusion occurs, and on cooling free cementite is not seen. The temperature required for solution of the cementite depends on the degree of agglomeration of the latter [see Abs. 1630 (1921)].

F. C. T.

661. Distribution of Temperature in Steel Ingots during Cooling. **S. Saitô.** (Tôhoku Univ. Sci. Reports, 10. pp. 305-330, Oct., 1921. 52nd Report from the Iron and Steel Research Inst.)—The rate of cooling of cylindrical and prismatic ingots has been investigated, together with the rate of heating of such ingots when placed in a furnace. Numerical

examples are worked out which are of distinct interest, although several assumptions are made, such for instance as the surface condition, which can be no more than first approximations. The heat-changes at the recalescence points are neglected. The heating of the ingot mould is also considered, and it is of interest that the calculations agree well with the results of actual trial. An attempt is also made to determine the stresses set up as a result of the temperature differences, but owing to the fact that the material is considered to be non-plastic, some of these results are obviously too high. The conditions in a thick plate appear to be made to correspond with those in armour-plate manufacture. The insertion of worked out examples is a very valuable addition to the purely mathematical treatment.

F. C. T.

662. *The Constitution of the Alloys of Copper with Tin.* III and IV. J. L. Haughton. (Inst. of Metals, J., 25. pp. 309-330; Disc., 331-336, 1921. Engineering, 111. pp. 789-793, June 24, 1921.) [For Parts I and II see Abs. 1475 (1915).]—Part III. An investigation into the transformations occurring below 250° C. in copper-tin alloys containing more than 40 % of tin. It is shown that, in addition to the eutectic, there are two transformations, one occurring in alloys containing between 40 % and 61 % Sn at 210° C., and the other occurring over the whole range at about 185° C. The latter is probably a polymorphic modification of the ϵ constituent of the alloys, but no explanation can be found for the former transformation.

Part IV is a determination of the solubility of copper in tin. This is found to be very small—about 0.2 %. An appendix is added referring to work on the series published since the author's previous paper. In the discussion, C. H. Desch referred to the similarity of the thermal curves to those obtained with certain alloy steels, and suggested that the arrests might be due to a constituent in a minutely divided form, which only dissolved very slowly, though he considered that the electrical resistance measurements contradicted this explanation. O. F. Hudson said that his experience with regard to the solubility of copper in tin agreed with the author's. T. E. Rooney stated that liquation experiments appeared to show that the composition of the eutectic was nearer 0.5 % Cu than 1 % Cu. J. L. Haughton, in reply, suggested a way in which the 210° C. line could be explained as being due to the separation of a constituent from solution, the explanation being at the same time compatible with the results obtained by electrical resistance measurements.

J. L. H.

663. *Graphitisation in Iron-Carbon Alloys.* K. Honda and T. Murakami. (Tôhoku Univ., Sci. Reports, 10. pp. 273-303, Sept., 1921. 51st Report from the Iron and Steel Research Inst.)—Gives the results of an investigation undertaken to determine the period of graphite formation in iron-carbon alloys during cooling, the condition of its occurrence, and the mechanism of graphitisation. The material used in the experiments consisted of a white pig iron containing 3.75 % carbon and exceptionally low in impurities. The results show that the graphite in pure cast-iron is produced by the decomposition of solidified cementite during cooling, and not by a direct separation from the melt. Flaky graphite is also obtained by annealing the solidified alloy at a temperature a little below the eutectic point. The formation of graphite is not a direct de-

composition of cement, but is due to a catalytic action of gases such as CO or CO₂. The mechanism of the catalytic action is probably due to a minute quantity of CO₂ coexisting with CO as the temperature falls from the melting-point and the reaction of this gas on the cementite thus: $\text{Fe}_3\text{C} + \text{CO}_2 = 2\text{CO} + 3\text{Fe}$; this diminution of the amount of CO₂ present causes a further dissociation of CO thus: $2\text{CO} = \text{CO}_2 + \text{C}$, reproducing the dioxide, which reacts with cementite. These two reactions, being continuously repeated in the alloys, graphite is gradually produced from the cementite. The most favourable temperature for the graphitisation is below the eutectic point, but above 1100°, and as the temperature decreases, graphitisation becomes always less. The graphitisation during cooling depends on the rate of cooling through the range of 1100°, as well as on the condition of the melting before cooling. The slower the rate of cooling, the more the graphitisation increases in extent. The melt containing CO graphitises easily. The graphitisation during cooling becomes less as the max. temperature during melting increases, probably owing to the decrease of solubility of the gases. The mixing of air or iron oxide during melting has a great effect on graphitisation, CO and CO₂ being formed by its reaction with carbon. The graphitisation by annealing depends on the temperature and the time of annealing, and also on the content of CO or CO₂ or iron oxide in the specimen. During annealing, graphitisation proceeds rapidly at first, and afterwards becomes less, finally attaining a practically constant value. C. O. B.

664. Properties of Molybdenum Steel. **A. H. Hunter.** (Chem. and Met. Eng. 25. pp. 21–22, July 6, 1921. Extract of a paper read before the Am. Iron and Steel Inst., May, 1921.)—Molybdenum steels, when treated to give the same tensile strength as other steels, have a higher elastic ratio, greater ductility, and a considerably greater toughness. In a series of Izod tests carried out on straight carbon steels and alloy steels, it was found that a chrome molybdenum steel had an impact resistance 34 % greater than the best of the other materials. A low-carbon steel with about $\frac{1}{4}$ % of Mo is exceptionally ductile, and is suitable for the manufacture of sheets and pressed steel parts. A number of tables showing the mechanical properties of molybdenum and other steels are given. J. L. H.

665. The Surface of Liquid Steel. **C. Johns.** (Engineering, 112. p. 619, Oct. 28, 1921. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—The author brings forward further proof for a theory advanced previously [Abs. 1253 (1919)] that the surface of a stream of liquid steel is protected from oxidising by being surrounded with an envelope of iron vapour. From a few feet above the surface of the molten steel, he collected, by means of a magnet, samples of the fume which arose from the metal. This was analysed, and the results, recalculated on an-oxygen free basis, differed from the composition of the steel. This is what would be expected if the fume were vapour from the steel and not a fine spray, as the constituent elements of the steel would not be likely to volatilise at the same rate. J. L. H.

666. Failure of Metals under Internal and Prolonged Stress. (Faraday Soc., Trans. 17. pp. 2–215, Dec., 1921.—General Discussion.)—After VOL. XXV.—A.—1922.

an introductory address by W. Rosenhain, five papers of a general character were read, including "Chemical Influences in Failure of Metals Under Stress," by **C. H. Desch**; "Failure of the Lead Sheathing of Electric Cables," by **L. Archbutt** [abstracted separately]; "Mechanism of Failure from Internal Stress," by **W. H. Hatfield** [abstracted separately]; "Internal Stresses in Brass Tubes," by **R. H. N. Vaudrey** and **W. E. Ballard** [abstracted separately]. After this a large number of papers on failures in steel and brass were presented and discussed. Owing to the space which would be required to deal with these individually, only those papers which appear to contain the results of experiments not previously published are abstracted separately, as indicated: "Fractures in Locomotive Boiler Tubes," by **H. Fowler**; "Intercrystalline Fracture in Steel," by **D. Hanson**; "Intercrystalline Fracture of Mild Steel in Salt Solutions," by **J. A. Jones**; "Internal Fractures in Steel Rails," by **H. S. Rawdon**; "Internal Service-Strains in Steel," by **J. E. Howard**; "Failure Through Action of Internal Stress Irregularities," by **N. Greenwood** [abstracted separately]; "Failure of Steel Upon and After Hardening," by **G. W. Green**; "Prevention of Season Cracking in Brass," by **H. Moore** and **S. Beckinsale**; "Experiences of Season Cracking," by **O. W. Ellis**; "Spontaneous Cracking of Cart-ridge Cases," by **W. C. Hothersall**.
L. H. W.

667. Hardening Cracks in Tool-Steel. S. N. Brayshaw. (Iron and Steel Inst. J. 103. pp. 131-216; Disc., 217-249, 1921.)—A description of a very large number of experiments relative to the prevention of hardening cracks in milling cutters made from a steel containing 1.1 % C and 0.8 % W. The changes which occur in the steel in the neighbourhood of the critical points were studied by means of a large number of bars which, after soaking for various periods of time, at temperatures near the critical points, were quenched in water, or, in the case of a second series, cooled in sand. The tendency of the steel to crack in hardening was correlated with the results obtained from the bars by means of a series of milling cutters made of a design very difficult to harden. The cutters were made out of blanks which had been heat-treated with the bars. After machining, the cutters all underwent the same standard hardening process. Apparently there is, at any rate for the particular steel examined, a range of temperature (715° C. to 725° C.) within which the metal, if soaked for a sufficiently long time, reaches a condition in which liability to crack during hardening is greatly reduced. Cutters made from blanks in which the ratio of Brinell hardness to scleroscope hardness was high, generally broke badly in hardening. In the *discussion*, **C. Benedicks** analysed the causes of cracking, and suggested that a definite shape of test prism would give nearly the same quenching results as the milling cutter, and would be very much simpler to make.
J. L. H.

668. The Liquefaction of Carbon. E. Ryschkewitsch. (Zeits. Elektrochem. 27. pp. 445-452, Oct. 1, 1921.)—A modification of the type of furnace formerly applied for the melting of carbon consists in the use of a graphite rod 4 cm. long with a square cross-section of 1.5 cm.², mounted between carbon electrodes in an enclosed space and provided with a narrow area in the centre to attain the max. temperature. On passing a current of 700-900 amps. at 12 volts, a sudden interruption of the circuit occurred after about 15 mins. due to fusion of the graphite.

On opening the furnace, after allowing to cool, the edges of the graphite rod were seen to be smooth, soft, and lustrous, while around the sides there occurred a deposit consisting of a cluster of numerous solidified drops mostly of 0.5 to 1.5 mm. diam. At the point of contact with the rod, the drops were elongated while the free ends were of spherical form and widened. It is inferred from this that the surface tension of the liquid carbon is high. The ash content of the graphite before use amounted to 0.08 %, while the quantity in the solidified globules was below the limits of gravimetric determination. The globules were moderately hard and marked paper similarly to graphite. Another variety of product obtained in some cases consisted of larger masses of graphite of an extremely soft and highly lustrous form. That the observed phenomena are due to fusion, and not sublimation, of carbon is supported by the sudden interruption of the current, in place of the gradual increase of resistance which would be expected with sublimation, and also by the glazed appearance of the edges of the graphite after the separation. The melting-point of graphite is close to the boiling-point, and success in the production of the fused material depends on so insulating the graphite that the melting-point is reached with a minimum current density.

No definite crystalline structure in the fused globules could be detected by the microscope. However, in a further procedure in which graphite in the form of fine scales was arranged as the resistance path in a furnace through which a heavy current was passed, well-formed individual crystals of a soft, flexible, and elastic nature were produced. These arise during the heating by the accretion of larger particles at the expense of smaller ones. The crystals were in the form of hexagonal plates with an interfacial angle of 120° . The symmetry is that of the trigonal system, the three perpendicular axes being considered to correspond to the three main valencies of the carbon atom as exhibited in the structure of the benzene ring [see Abs. 1317 (1921)].

J. N. P.

669. The Lewis Theory of Velocity of Chemical Reaction. T. W. J. Taylor. (Nature, 108. p. 210, Oct. 13, 1921.)—W. C. McC. Lewis has recently suggested that the negative result of exposure to sunlight on the velocity of reaction, in the case of the inversion of cane-sugar by dilute acid, obtained by F. A. Lindemann [Abs. 1180 (1921)] does not disprove his theory; for any such effect as an increase of 5×10^{13} times, deduced by Lindemann from his theory, was, under the conditions under which such a reaction is usually carried out, not to be expected, because the activating rays lie in the region of 1μ , and at this wave-length water, the solvent, would absorb the radiation almost totally in the first thin layer, so that the bulk of the liquid would not be affected. To test this possibility the author divided a solution containing 100 gm. of cane-sugar and 3.65 gm. of HCl per litre into two portions. One was placed indoors (room-temp. 14.7°C .), while the other was forced upwards through four fine jets from 3-mm. glass tubing drawn to the narrowest of capillaries, on the roof in full sunshine. The jets broke into drops at a height of about 8 cm., and rose a further 40 cm., and were collected in a dish, the resulting temperature being 19.1°C . The time for half inversion at 20°C ., from Lewis's measurement of the velocity constant, was 1.6×10^5 secs., or approximately 47 hours, which, on Lewis's hypothesis should be reduced by the sun to 3×10^{-9} sec., so some of the increased reaction velocity in the latter case was to be expected. The rotations measured

were: Unexposed solution, $13^{\circ}\cdot06$; exposed solution (two minutes later) $12^{\circ}\cdot82$. There was, therefore, no appreciable exposure effect. The size of the drops, measured afterwards, was found fairly constant, the average diameter being $0\cdot015$ cm. Further, from Stokes' formula, the size gives an average time of fall $0\cdot68$ sec., so that the time of exposure was more than ample. For even if the radiation density at 1μ had been reduced inside each drop, by absorption, to 10^{-8} of its value, which is unlikely, a rough calculation shows that the polarimeter readings should even then differ by about 13° instead of the observed $0\cdot24^{\circ}$. The author realises that this experiment has no bearing on Perrin's version of the radiation hypothesis, in which the reactants are supposed to absorb several quanta of considerably longer wave-lengths than 1μ to 2μ . The author is now arranging to put this also to experimental test.

G. W. DE T.

670. *Catalysis of Hydrogen-Oxygen Mixtures at Ordinary Temperatures of Water-wetted Contact Substances II. The Platinum Metals as Hydrogen Carriers.* K. A. Hofmann and L[otte] Zipfel. (Deutsch. Chem. Gesell., Ber. 53. pp. 298-314, Feb. 14, 1920.)—According to Willstätter platinum is a good hydrogen carrier so long as it contains oxygen. Hofmann and R. Ebert (*ibid.*, 49. pp. 2369-2389, 1916) had assumed that the oxygen remaining in the platinum metals (Pt, Pd, Ir) facilitated the formation of H_2O , but the authors suggest now that there are two forms of hydrogen-charged platinum metals, "fresh" and "aged." A contact previously charged with oxygen at once becomes a hydrogen-pole of abnormal activity, which reduces O to H_2O , and raises the H potential at the same time. In 20 or 30 minutes this activity diminishes, and the fresh contact becomes aged. Even in the complete absence of "poisons" the contact is not a constant factor (for given conditions of preparation and surface), but the catalytic efficiency depends upon the previous charge. Pre-treatment with oxygen is in the case of Pd (less so in the others) up to 50 times as effective as pre-treatment with hydrogen. There is a close parallelism between electromotive and catalytic activity; the maximum velocity of reaction is not always observed for the volume ratio $2H:1O$; it depends upon the rate of H saturation. H. B.

671. *Application of the Law of Mass Action to Strong Electrolytes, and Derivation of the General Equation of the Ionisation Isotherm.* W. Hughes. (Phil. Mag. 42. pp. 428-431, Sept., 1921.)—On the basis of the assumption previously made as to the nature of chemical force (*ibid.*, pp. 134-138, July, 1921), the author derives the following general relation between V , the total volume of a solution of an electrolyte, and α , the fraction of the ions which are in the act of forming molecules:

$$\frac{\alpha^2}{(1-\alpha)V\left\{f(V^{\frac{1}{2}})\right\}^{\frac{n_1-n_2}{2}}} = K'.$$
 This represents the general equation of the ionisation isotherm, the equations of Ostwald, Rudolphi, van't Hoff, and Partington being special cases thereof. T. H. P.

672. *Electrochemical Conceptions of Valency.* J. A. N. Friend. (Chem. Soc., J. Trans. 119. pp. 1040-1047, July, 1921.)—Thomson's physical theory of valency [Abs. 997 (1921)] is discussed, and is shown to offer interesting physical interpretations and support for many of the essential

features of the purely chemical "shell" theory of valency suggested by the present author. The latter theory, in its spacial relationships, closely resembles Werner's scheme in that the different groups of complex compounds are arranged at the angles of an octahedron, but it differs from Werner's theory in the following particulars: (1) It postulates the existence of only such valencies as are in harmony with modern physical conceptions of the atoms, and is essentially electrochemical. (2) The groups round the central metallic atom are assumed to be joined together by latent or non-ionised valencies, and not necessarily to the central atom itself. An explanation is thus furnished for the non-ionising character of the groups in the shell, and the central atom is not endowed with a high number of valencies. Werner's theory does not explain the non-ionising character of the complex ion, since that author himself showed that no distinction existed between his principal and secondary valencies. (3) The shell theory explains many phenomena both with simple inorganic substances and with complex salts which cannot be explained by Werner's theory. (4) When models of optically active cobalt complexes are constructed in accordance with the shell theory, it can be shown that the activity is due, not to an asymmetric arrangement round the cobalt atom, as Werner suggested, but to the presence of an asymmetric nitrogen atom.

T. H. P.

673. *Use of the Water Interferometer for the Analysis of Non-Aqueous Solutions.* **E. Cohen** and **H. R. Bruins.** (K. Akad. Amsterdam, Proc. 24. 1. 2 and 3. pp. 114–122, 1921.)—It is pointed out that, for the analysis of highly diluted solutions, the accuracy of the results obtained with the refractometer is insufficient, the water interferometer of Rayleigh and Löwe being more satisfactory for this purpose, yielding results accurate to 0.0002 % in the determination of concentration. The instrument is described and illustrated diagrammatically. Having been designed originally for the use of water, or very diluted alcohol, as solvent, special precautions, which are enumerated and discussed, must be observed, in order to carry the accuracy of measurements to the same order as can be reached with aqueous solutions.

A. B. C. L.

674. *The Physics and Chemistry of Colloids.* (Faraday Soc., Trans. 16. Appendix [190 pp.], July, 1921. Report of General Discussion held by the Faraday Society and the Physical Society.)—This Report, which has now been made available to the public through publication by the Department of Scientific and Industrial Research (obtainable at H.M. Stationery Office, 2s. 6d. net.) contains two introductory papers, namely: "The Physics and Chemistry of Colloids," by **T. Svedberg**, and "The General Structure of Colloids," by **W. Pauli**. Under *Emulsions and Emulsification* there is an "Introduction and Bibliography," by **F. G. Donnan**, and "Reversal of Phases in Emulsions," by **S. S. Bhatnagar**. In the section devoted to the physical properties of elastic gels there are four papers and a communication from Zsigmondy; these are: "Properties of Elastic Gels," by **E. Hatschek**; "Structure of Elastic Jellies," by **H. R. Procter**; "Reversible Sol-Gel Formation," by **S. C. Bradford**; "Structure of Gels," by **J. O. W. Barratt**. Other papers include one "On the Nature of Glass," by **M. W. Travers**, and five others in a section devoted to non-aqueous colloidal systems; of these papers only that dealing with "The Action of Light and Oxygen on Rubber," by **B. D. Porritt**,

need be referred to here. In the section devoted to precipitation of disperse systems there are seven papers, but only three of these need be mentioned, namely: "Theory of Precipitation of Disperse Systems," by **R. S. Willows**; "Origin of the Charge of a Colloidal Particle," by **J. N. Muckherjee**; "Electrical Theory of Adsorption," by **W. Harrison**. Then follow "Practical Applications of Electro-Endosmosis," by **W. R. Ormandy**, and "Effective P.D. of Electro-Osmosis," by **H. Freundlich**. Two appendices follow, the second, "On the Internal Pressure of Liquids," being by **H. K. Tompkins**. Those interested should refer to the original pages, as it is impossible, owing to lack of space, to deal at length with the individual contributions. L. H. W.

675. Measuring Gases Containing Water-Vapour. T. G. Estep. (Chem. and Met. Eng. 25. pp. 329-331, Aug. 24, 1921.)—Error arising in measurement of gases due to their water-vapour content is shown to be considerably greater than errors due to observation. The velocity formulæ applicable to measurement by Pitot tubes, Venturi meters, orifices and throttle discs are given, and involve a variable differential pressure dependent upon the density of the gas under the conditions at the point of measurement. An example is selected and the method of calculation described, illustrating the laborious nature of the determination of this function. A set of curves is given showing the variation of specific gravity of gases when saturated with water-vapour at different temperatures and the method of use of these curves to facilitate the determination of the density of the gas at the point of measurement is indicated. The variations to be adopted in the case of partially saturated gases are then described. A. B. C. L.

676. Solutions of Metals in Non-Metallic Solvents. VI. Conductance of Alkali Metals in Liquid Ammonia. C. A. Kraus (Am. Chem. Soc., J. 43. pp. 749-770, April, 1921.)—The molecular conductivity of solutions of sodium and potassium in liquid ammonia increases with dilution to a limiting value of over 1000, as compared with a maximum value for 340 for salts such as potassamide. It is suggested that these solutions contain a positive (metallic) carrier, or ion, which is identical with that in solutions of metallic salts, but that $\frac{2}{3}$ of the conductivity is due to a negative carrier of much greater mobility. This is perhaps an electron with solvent molecules condensed round it, and experiments have indicated that this is 20 times more mobile than the negative electrons produced by radiations in hexane, which have a velocity of $4 \cdot 17 \times 10^{-4}$ per volt-second, as compared with $91 \cdot 7 \times 10^{-4}$ for the negative carrier in liquid ammonia; the fluidities of the two solvents are similar (376 for NH_3 , 312 for C_6H_{14}), but the unequal condensation of solvent molecules is in accord with their unequal dielectric constants (22 for NH_3 and 1.85 for C_6H_{14}).

At a concentration of about 0.05 *N* the molecular conductivity passes through a minimum and then increases enormously, *e.g.*, to 3000 in normal and 80,000 in twice normal solutions. At the latter concentration the specific conductivity of the liquid is only 6 times less than that of metallic mercury. This high conductivity appears to be due again to the negative carrier (rather than to positive metallic ions) which increases enormously in mobility in the neighbourhood of normal concentration, perhaps because some of the electrons are freed from molecules of the solvent for a part of the time.

It appears that the solutions of the metals in liquid ammonia form the connecting link between electrolytes and metallic conductors. The conduction in these solutions is definitely ionic, but there is nothing to distinguish the conduction in strong solutions from that in pure metals. It is therefore probable that the process of conduction in metal is effected by the same negative carrier that is active in these solutions, and is probably identical with the negative electron.

The blue colour of the solutions is probably due to the negative carrier and not to the positive metallic ion, which appears to be identical with that which is present in colourless solutions of potassamide. T. M. L.

677. Molecular State of Water-Vapour. A. W. C. Menzies. (Am. Chem. Soc., J. 43. pp. 851-857, May, 1921.)—Various considerations concerning the ionisation and polymerisation of water, not dealt with by Kendall [Abs. 747 (1921)], are advanced. Firstly, the density of saturated water-vapour is recalculated by means of the Clausius-Clapeyron equation for various temperatures, modern data for the several factors involved being employed. The results obtained show that the density does not become less than the ideal value below 30° , that there is therefore no foundation for the hypothesis of spontaneous ionisation, and that the excess density for 100° computed from Regnault's data is about 100 % too high.

The numerous and concordant independent results obtained by Perman and by Krauskopf for the vapour pressure of water at temperatures averaging 73° by the gas-current saturation method are found to lead to a vapour density for saturated water-vapour at that temperature that is less than 0.1 % higher than the ideal value, whereas the value derived from the Clapeyron equation is 0.9 % higher; this discrepancy requires explanation. If Berthelot's equation of state is applied to the mean of these two results for 73° , the numerical basis remaining from which to postulate polymerisation of water-vapour at this temperature, is exactly zero. T. H. P.

678. Allotropic Varieties of Oxides (Magnetic Oxide of Iron). S. Veil. (Comptes Rendus, 172. pp. 1405-1407, June 6, 1921.)—When the temperature is rising the conductivity-temperature curve for magnetic oxide of iron exhibits a distinct double bend at $500-600^{\circ}$, which is approximately the Curie point. During fall of the temperature, the curve shows no peculiarity at the Curie point, the conductivity remaining higher than during the heating. Such behaviour may be due to the formation of an allotropic modification of the oxide. The corresponding curve for cadmium oxide exhibits two maxima with an intermediate minimum, the existence of three allotropic forms being thus indicated: the α - and β -forms having conductivities of the same order of magnitude, and the γ -form having a comparatively low conductivity. T. H. P.

679. Low-Voltage Standard Cells. J. Obata. (Phys. Math. Soc. Japan, Proc. 3. pp. 136-149, Nov., 1921.)—Full details of experiments are given, having for their object the discovery of a standard cell with e.m.f. of the order of 0.1 volt or less, convenient for measuring small e.m.f.'s with a high-resistance potentiometer having no current-reducing switch, e.g., the e.m.f.'s of thermo-couples and those due to galvanic and thermo-magnetic effects, and the calibration of millivoltmeters.

Various combinations of Cd and its amalgams and Pb amalgams are studied, the electrolytes being the haloid salts and sulphates of Cd and Pb. The most constant and easily reproducible found are

- (a) Cd amalgam | CdI_2 | PbI_2 | Pb amalgam ;
 (b) Cd amalgam (10 %) | $\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O}$ | Cd amalgam (dilute).

The e.m.f. of (a) is 0.09838 at 20° C., and that of (b) is of the order of 0.01 volt, giving different values according to the concentration of the dilute amalgam. The temperature coefficients of the various combinations tried are given in tabular form. Two particular cells (chloride and iodide) are indicated having temperature coefficients opposite in sign and similar in magnitude which can be combined to give a low-voltage standard of 0.2434 volt at 20° C. with a temperature coefficient of +0.00004 volt per deg. C.

The relationships of the results obtained to the heats of formation of the haloid salts of Cd are studied by application of the Gibbs-Helmholtz equation, fairly good agreement with the data obtained by thermochemical means in the cases of the chloride and iodide being shown, but less so with the bromide.

A. B. C. L.

680. Electro-Deposition and Electroplating. (Faraday Soc., Trans. 16. pp. 473-553, July, 1921.—General Discussion.)—In this Discussion the following papers on general aspects of electro-deposition were read: "Electroplating for the Prevention of Corrosion," by **L. Aitchison**; "Applications of Electro-Deposition in Aeronautical Engineering," by **W. H. Thain** [abstracted separately]; "Electro-Deposition of Cobalt," by **B. Carr** [abstracted separately]; "Commercial Electrolysis of Zinc Sulphate Solutions," by **S. Field**; "Deposition of Gold-Silver Alloys," by **S. Field**; "Use of Colloids in Electro-Deposition," by **W. E. Hughes**. Further papers dealt with the subject of electroplating, namely: "Electro-Silver Plating," by **W. R. Barclay**; "Chemical Composition of Old Silver Plating Solutions," by **F. Mason**; "A New Maximum Current Density in Commercial Silver Plating," by **F. Mason**; "Crystalline Structure of Electro-Deposited Silver," by **G. B. Brook**.

L. H. W.

681. Kathodic Reduction of Dissolved Elementary Nitrogen. **E. Tiede** and **A. Schleede**. (Zeits. Elektrochem. 27. pp. 112-114, March 1, 1921.)—To repeat the early experiments of Davy and those of Rayleigh, two glass tubes of about 2 cm. diam. were connected near the base by a tube 1 cm. diam., filled with asbestos. Electrodes of gold-foil were held in the two vertical tubes by wires sealed through the walls. The tubes were filled with distilled water, closed at the top with rubber stoppers and a potential of 220 volts was applied to the electrodes for a period of 2 days. No acid or alkali could be detected at the electrodes by litmus, nor ammonia by Nessler's reagent. A similar negative result was obtained with Pt electrodes, and when the water was maintained saturated with nitrogen gas. In another type of apparatus, a cylindrical vessel was used in which anolyte and catholyte were separated by a porous alumina cell. Mercury was used as cathode and Pt as anode. Traces of ammonia were obtained which were found, however, to be derived from the porous cell and to be independent of the current. Solutions of sulphuric and acetic acids were then applied as the electrolyte in different experiments. The acetic

acid was used at a concentration of 50 % on account of the high solubility of this solution for nitrogen. Different metals were employed for the kathode and current densities from 0.01 to 1 amp./cm.². The results again all failed to show the formation of ammonia. Experiments were then conducted at high gaseous pressures with an apparatus fitted with a central kathode compartment containing a stirrer operated by a motor. A kathode of amalgamated Au was used, an electrolyte of 0.1 % sulphuric acid, and, in the outer compartment, an anode of Pt.

At pressures of 100–150 atmos., when a diaphragm of glass-wool contained in tubes was used, no ammonia could be detected after an electrolysis extending over a period of one hour. J. N. P.

682. *Cause of the Periodic Phenomena during the Electrolysis of Chromic Acid, and the Separation of Metallic Chromium.* **E. Liebreich.** (Zeits. Elektrochem. 27. pp. 94–110, March 1, 1921.)—During the electrolysis of chromic acid, periodic fluctuations of the voltage accompanied by inverse changes of the C.D. are found to occur at both electrodes, but the main effect is obtained at the kathode. Measurements were made with an anode of platinum and kathodes of different metals. With an iron kathode and an electrolyte of 100 gm. CrO₃ to 100 gm. water, a break in the current curve as plotted against the voltage occurs at 1.7 to 1.8 volt, corresponding to the decomposition potential of chromic acid. Beyond this point the current increases regularly with increasing potential until, at 2.84 volts, the potential rises suddenly to 3.25 volts, while the C.D. falls from 0.283 to 0.279 amp./cm.². From this point the voltage changes to 2.82 volts, slowly increases to 2.84 volts, when the voltage oscillates for a time and then returns to 3.25. This cycle of changes is then repeated, and constitutes the periodic phenomena. With a platinum kathode a similar type of curve is obtained, and on increasing further the applied potential, the current and potential pass through a cycle of changes similar to those at the lower voltages. Four breaks in all can be observed at the different potentials. The same changes are observed with kathodes of Fe and Cr, except that in these cases the metal dissolves at the kathode whenever the film formation takes place. The periodic phenomena are independent of the nature of the kathode and have no relation to the passivity of the metal. The oscillation periods are partly determined by the rate at which the film of lower oxides falls from the surface of the kathode and is replaced by the unreduced chromic acid, thus causing periodic concentration changes determined by convection and diffusion.

The electrolytic deposition of Cr may be effected not only at high current densities, but even with a C.D. as low as 0.02 amp./cm.² when the solution is slowly reduced so as to provide CrO. Reduction by this means at the lower C.D. provides a bright adherent deposit of metal with a current efficiency of about 10 %. With a C.D. of 0.5 amp./cm.², the metal is deposited in the form of a loose grey powder. With 1 amp. and higher per cm.², the Cr is deposited in a crystalline but non-adherent form. At still higher densities, in place of metal, a green deposit of CrO₃ is obtained, due to the electrolyte becoming neutral. J. N. P.

683. *Electrode Phenomena in the Presence of Colloids.* **N. Isgarischew** (Kolloidchemische Beihefte, 14. Nos. 1–2, pp. 25–62, Sept. 1, 1921.)—By means of curves showing the relation between current density and the

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p.d. between the electrode and the surrounding electrolyte, measurements of anodic and cathodic polarisation were made during the electrolysis of zinc sulphate solutions in presence of gelatine, gum arabic, and sugar, and with copper sulphate in presence of gelatine, and determinations were made of the viscosity and electrical conductivity of the electrolytes. The addition of the smallest amounts of gelatine caused an increase in the cathodic potential during electrolysis. With normal zinc sulphate solution, max. values of the polarisation were obtained by the addition of 0.025 % gelatine, 2 % gum arabic, 30 % sugar, and in copper sulphate solution with 0.30 % gelatine. With larger amounts of colloid the polarisation values fell. The viscosity of the solutions was not appreciably affected by the presence of gelatine and gum arabic when present in amounts below the above critical concentrations. Above these values, the viscosity increased rapidly with the concentration of the colloid. The electrolytic conductivity of the solutions in all cases was only slightly increased by the colloid. No perceptible influence on the dielectric constant was observed. Anodic polarisation was unaffected by the presence of colloid, but, in the case of sugar, gave values similar to the cathodic polarisation. The phenomena observed are attributed to the formation of a complex or adsorption compound between the zinc ion and the gelatine molecule which is in equilibrium with free zinc ions and dissociates with a measurable and retarded reaction velocity before liberation as free atoms. The critical concentration of colloid represents the stage when all the free ions of metal are saturated and the polarisation has its max. value, while at higher concentrations of colloid the degree of dispersion is lowered and the formation of complexes hindered. The theory is further borne out by the observation that with more concentrated salt solutions the max. polarisation was obtained with a higher concentration of colloid. The polarisation with sugar is attributed to chemical combination between the sugar and zinc sulphate.

The stationary potential of zinc in zinc sulphate is progressively lowered by increasing concentrations of gelatine. By means of the Gibbs-Helmholtz relation the heat absorbed in the formation of the complex of zinc ion and gelatine at the above critical concentration is calculated to amount to 2150 cal. per gm. atom of zinc.

Examination by the ultra-microscope of the solutions under investigation showed a characteristic change in the appearance of the particles on the addition of colloid. A microscopic examination of the electro-deposited metal showed a definite relation to exist between the degree of polarisation and the structure of the metal. The amorphous structure and smoothness of the metal deposited in presence of colloid is attributed, as with polarisation, to the slow rate of formation of free ions from the complex with the colloid, in the stage immediately preceding the liberation of free atoms of metal.

J. N. P.